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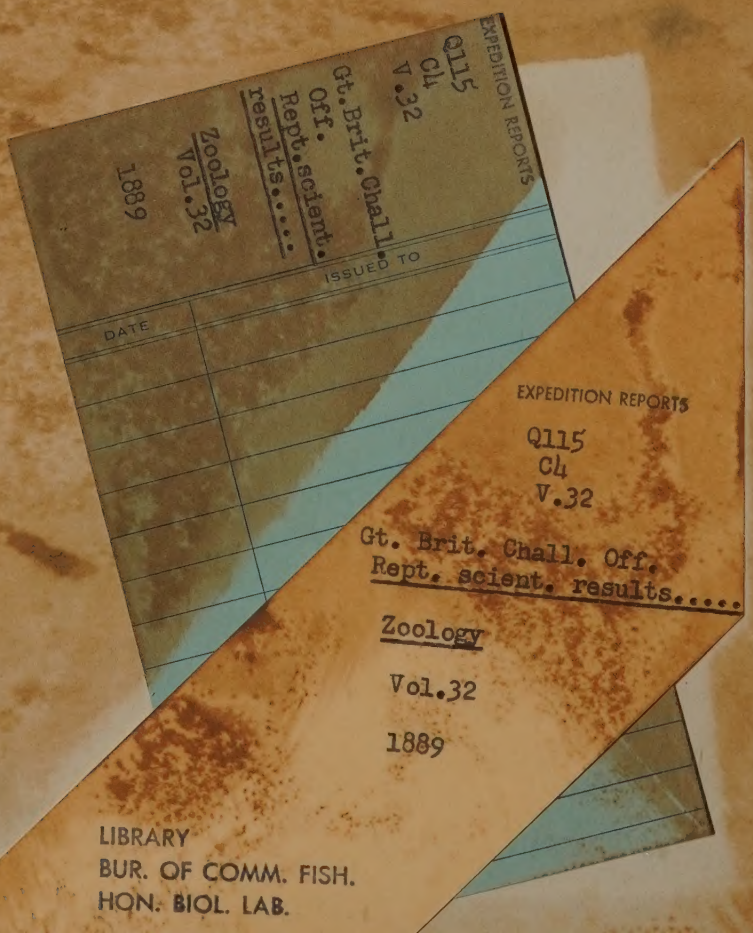

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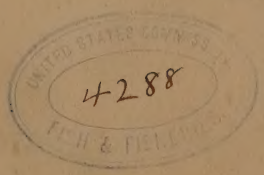
THE

VOYAGE OF H.M.S. CHALLENGER.

ZOOLOGY—VOL. XXXII.



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REPORT

ON THE

SCIENTIFIC RESULTS

OF THE

VOYAGE OF H.M.S. CHALLENGER

DURING THE YEARS 1873-76

UNDER THE COMMAND OF

CAPTAIN GEORGE S. NARES, R.N., F.R.S.

AND THE LATE

CAPTAIN FRANK TOURLE THOMSON, R.N.

PREPARED UNDER THE SUPERINTENDENCE OF

THE LATE

Sir C. WYVILLE THOMSON, Knt., F.R.S., &c.

REGIUS PROFESSOR OF NATURAL HISTORY IN THE UNIVERSITY OF EDINBURGH

DIRECTOR OF THE CIVILIAN SCIENTIFIC STAFF ON BOARD

AND NOW OF

JOHN MURRAY, LL.D., Ph.D., &c.

ONE OF THE NATURALISTS OF THE EXPEDITION

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CONTENTS.

I.—Report on the Antipatharia collected by H.M.S. Challenger during the years 1873–1876.

By George Brook, F.L.S., F.R.S.E.

(*The Manuscript was received in Instalments between* 29*th December* 1888 *and* 22*nd July* 1889.)

II.—Supplementary Report on the Alcyonaria collected by H.M.S. Challenger during the years 1873–1876.

By Professor Th. Studer, M.D.

(*The Manuscript was received* 28*th December* 1888 *and* 1*st March* 1889.)

III.—Report on the Deep-Sea Keratosa collected by H.M.S. Challenger during the years 1873–1876.

By Professor Ernst Haeckel, M.D., Ph.D., Hon. F.R.S.E.

(*The Manuscript was received* 14*th March* 1889.)

EDITORIAL NOTES.

This Volume contains Parts LXXX., LXXXI., and LXXXII. of the Zoological Series of Reports on the Scientific Results of the Expedition.

Part LXXX.—About a year ago Mr. George Brook, Lecturer on Comparative Embryology in the University of Edinburgh, was induced by me to undertake the examination and description of the small group of Antipatharia collected during the Expedition. Since the collection was placed in his hands Mr. Brook has devoted nearly the whole of his time to the investigation. The accompanying Report, which may be regarded as a Monograph, shows what large additions have been made to our knowledge of the morphology of this interesting group of deep-sea animals.

The Report consists of 222 pages of letterpress, illustrated by 15 lithographic plates and numerous woodcuts.

Part LXXXI.—This is a Supplementary Report by Professor Studer on a few species of Alcyonaria, which were found in his possession too late to be included in the Report on the Alcyonaria, by Professors Wright and Studer, published in January last (Part LXIV. Vol. XXXI.).

The Report includes a summary of the geographical and bathymetrical distribution of the Alcyonaria, and consists of 31 pages of letterpress, with 6 chromo-lithographic plates.

Part LXXXII.—In this Part Professor Ernst Haeckel makes his fourth contribution to the Challenger series of Zoological Reports, and here deals

with a group of Deep-Sea Keratosa. These are interesting from the symbiosis with Hydroids, from the mass of the pseudo-skeleton, consisting of the materials of deep-sea deposits, from the primitive forms described under the name Ammoconidæ, and the difficulties which were experienced by many naturalists in determining the true nature of these remarkable organisms.

The Report extends to 92 pages, accompanied by 8 chromo-lithographic plates.

This volume concludes the Zoological Series of Reports on the Scientific Results of the Expedition, with the possible exception of a few supplementary notes to some of the memoirs and Professor Huxley's Report on the genus Spirula, which may appear as an appendix to the concluding Summary Volume.

The first volume of these Zoological Reports was issued in 1880, and the others have appeared at short intervals up to the present time. During the same period there have been issued from the press two Botanical Volumes, one volume of Physical and Chemical Researches, and three volumes of the Narrative of the Cruise with appendices. A second Physical and Chemical Volume will be published within the next two months; the volume on Deep-Sea Deposits will follow next year, and the whole work will be completed in a Summary Volume.

As the Biological Series of Special Reports may now be said to have been completed, there is appended a list of these arranged, first, according to the subject matter, and, second, according to the contents of each volume. Of Zoological Reports there are *nine* Reports (in 12 Parts) dealing with the Vertebrata; *one* Report (in 3 Parts) dealing with the Tunicata; *thirteen* Reports (in 17 Parts) dealing with the Molluscoidea and Mollusca; *fourteen* Reports (in 16 Parts) dealing with the Arthropoda; *five* Reports (in 7 Parts) dealing with the Echinodermata; *five* Reports (in 6 Parts)

dealing with the VERMES; *fifteen* Reports (in 18 Parts) dealing with the CŒLENTERATA; and *three* Reports (in 3 Parts) dealing with the PROTOZOA. Of Botanical Reports there are *three* Reports dealing with the BOTANY OF OCEANIC ISLANDS, and *one* Report on the Marine DIATOMACEÆ.

These Biological Reports have been issued, whenever ready, and without any reference to systematic arrangement of the subjects treated of, in eighty-seven separate parts, and as thirty-four volumes of Reports, the whole, together with the illustrations, being bound up in forty-two large quarto volumes. These volumes contain 24,700 pages of letterpress, 2600 quarto lithographic and chromo-lithographic plates, with many maps and numerous woodcuts.

The Biological Reports have been contributed by sixty-two separate authors, forty-two of whom are resident in the United Kingdom, India, and the British Colonies, seven in Germany, three in the United States, two in Holland, and one in each of the following countries, viz., France, Russia, Sweden, Norway, Denmark, Switzerland, Belgium, and Italy, so that nearly all civilised countries have taken part in the production of this great work. The cosmopolitan or international nature of the undertaking becomes still more evident, if account be taken of the large number of naturalists and others, in different parts of the world, who have in various ways assisted the several authors and the editor while carrying on their investigations.

For my own part, I desire now to record my indebtedness, and to convey my thanks to all the contributors, and to all those who have, by the loan of specimens, books, and manuscript, by information and advice, or in any other way, assisted me in carrying to a successful issue the biological work connected with these reports on the Scientific Results of the Expedition.

All the type specimens referred to in the Zoological Reports have been, or will be, within the next few months, placed in the British Museum. It is somewhat remarkable that although the various Challenger Collections

have been transported to and from so many distant parts of the world, they have as yet met with no accident. The Botanical Collections are in the National Herbarium at Kew.

JOHN MURRAY.

CHALLENGER OFFICE, 32 QUEEN STREET,
EDINBURGH, *6th September* 1889.

I.—LIST OF THE CHALLENGER ZOOLOGICAL REPORTS ARRANGED IN SYSTEMATIC ORDER.

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THE

VOYAGE OF H.M.S. CHALLENGER.

ZOOLOGY.

REPORT on the ANTIPATHARIA collected by H.M.S. Challenger during the Years 1873–76. By GEORGE BROOK, F.L.S., F.R.S.E., Lecturer on Comparative Embryology in the University of Edinburgh.

PREFACE.

IN June 1888 I was invited by Dr. John Murray to prepare a Report on the Antipatharia obtained by the Challenger Expedition, and the majority of the specimens were soon afterwards placed in my hands for identification.

Probably no group of marine animals has received so little systematic attention during recent years as the Antipatharia, and our knowledge of their morphology has hitherto been confined to a partial study of two or three species. The descriptions of genera and species alike have been almost entirely based on skeletal characters, and prior to the Challenger Expedition probably few specimens were in existence, the polyps of which were well preserved. During the recent "Blake" and "Hassler" expeditions, a number of new and interesting species were brought to light by the United States Coast Survey, which have been described by Pourtalès, but no attempt has been made to rearrange the species already known in the light of these newer investigations.

It soon became apparent that the Challenger collection, although not large, offered exceptional facilities for a morphological study of the group, many of the more important features of which have hitherto escaped notice. I have, therefore, taken this opportunity of attempting a partial revision of the Antipatharia, and have endeavoured, so far as opportunity would allow, to place the classification on a more natural basis. In the time at my disposal I have been unable to visit many of the more important Continental collections, and have relied chiefly on a comparison of the collections of the

British Museum, and of the Zoological Museum at Copenhagen, for the identification of species described by the earlier authors, the majority of which are very imperfectly characterised. The British Museum collection is very extensive, and contains representatives of over 40 species, including most of the types described by Gray. Unfortunately very few of the specimens are preserved in spirit, and as the polyps of a large number of species are still unknown I have been unable to suggest the generic position of several of them. Owing to the very imperfect description of the majority of the forms already known, and the consequent confusion in nomenclature which exists, it has appeared necessary to extend the scope of the present Report so as to include an account of the whole of the known Antipatharia. I trust that the additional information which I am enabled to give of all the species that have come under my notice, sixty-eight in all, will prove sufficient for their future identification. Undoubtedly a study of the fine collections of the Museum of Comparative Zoology at Harvard College would have rendered my work both easier and much more complete, but unfortunately this has been impossible. Professor Alexander Agassiz, to whom I am indebted for many acts of kindness, informs me that the specimens were handed to Professor Verrill for examination several years ago, and that they have not yet been returned.

The following pages include descriptions of 16 genera, 98 species and 4 varieties, of which 11 genera, 41 species and 2 varieties are new. Representatives of 9 genera, 19 species and 1 variety are included in the Challenger collection, all of which are new. The types of the remaining new species are all in the British Museum, with the exception of three; two of these are preserved in the Zoological Museum at Copenhagen, and the third is in the Museum of Comparative Zoology at Harvard College.

The fact that all the Challenger species are new is largely accounted for by the circumstance that nearly all the specimens were obtained in regions hitherto unexplored, or from which no Antipatharia had previously been recorded. The collection is remarkably deficient in littoral forms, whilst on the other hand quite a number of species have been shown to inhabit abyssal depths, a fact which has hitherto been unknown. The abyssal species present many new and interesting features, and are characterised by a type of dimorphism which is apparently not found in any other Zoantharia.

In the limited time allowed for the completion of my Report I have only been able, in addition to the systematic portion of the work, to prepare a preliminary account of the anatomy of the Antipathinæ. The structure of the Schizopathinæ will form the subject of a future paper, which I hope to finish before the end of the year.

I desire to acknowledge gratefully the privileges afforded me by Dr. Albert Günther of the British Museum, Professor Chr. F. Lütken of Copenhagen, Mr. Charles Stewart of the Museum of the Royal College of Surgeons, London, and Mr. Moore of the Liverpool Free Museum, all of whom have rendered me every facility for an investigation of the collections under their charge.

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The drawings have been chiefly made under my supervision by my assistant Mr. F. G. Binnie, but Plates XI. and XII., together with a number of the histological figures, have been drawn by Mr. James T. Murray.

In conclusion I desire to express my warmest thanks to Dr. John Murray for having given me the opportunity of investigating such a little-known group of animals, and for his many acts of kindness and assistance during the progress of my Report. My thanks are also due to Mr. James Chumley of the Editorial Staff for the trouble he has taken with my proof-sheets.

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CRITICAL REVIEW OF LITERATURE.

Our knowledge of the Sclerobasic or Black Corals may be said to date from the publication of the Elenchus Zoophytorum of Pallas in 1776, previous authors, including Linnæus, not having recognised their essential difference from the Gorgonidæ. Several species were already known and figured in the works of Rumphius, Seba, Marsigli, and others, but these, with the exception of two or perhaps three, first received a place in the binomial system at the hands of Pallas. Two forms are included in the 10th edition of the Systema naturæ under the genus *Gorgonia*, viz., *Gorgonia abies*, Linnæus, and *Gorgonia spiralis*, Linnæus, whilst *Gorgonia ænea*, Linnæus, is perhaps synonymous with the former species.

The work of Pallas is remarkable for its clearness and precision; in it we first find clearly stated those characters which still are of ordinal value amongst the Antipathidæ. It is true that the chief characters of his new genus *Antipathes*, new rather by definition than in name, rested on points of skeletal structure, and little was known at that time, nor indeed until quite recently, about the structure and organisation of the polyps. Nevertheless the words of Pallas—"Stirps cornea; extus scabra, attenuata; cortice gelatinoso," define the Antipathidæ as clearly to-day as they did a century ago, and separate them from all other known Zoantharia. This is all the more remarkable when it is remembered how much the horny skeleton of Hydroids and Actinozoa is subject to variations within limited groups; how even species of the same genus may differ in this respect. Yet with regard to the Antipathidæ the structure of the skeleton alone is sufficient to separate them from other forms. Had subsequent investigators been more careful in following the characters laid down by Pallas, much confusion and error might have been avoided. The possession of a spinose horny axis has proved to be such an essential character of all Antipathidæ, that those which have been described as smooth have either been erroneously so described, or do not belong to the family at all.

At a time when nothing was known of the structure of the polyps, it was only natural that the species of *Antipathes* should be regarded as closely allied to *Gorgonia*, to which indeed their dendritic sclerobasic axis seems very closely allied. The similarity

between the mode of growth of those fan-like forms included in Milne-Edwards' division *Rhipidipathes* and some species of *Rhipidogorgia*, *Echinogorgia*, &c., is most marked, and has led Esper and others into numerous errors of identification. In the absence of polyps, the nature of the cœnenchyma and the presence of spines form the only reliable characters at the present day by which the Antipathidæ may be identified. Ellis and Solander in speaking of *Antipathes cupressina*, Pallas (= *Gorgonia abies*, Linnæus), put the matter very clearly, so far as the differences were known at the time. They say, "Linnæus has classed this species under *Gorgonia*, to which it is very nearly allied ; but the flesh of this tribe is so remarkably gelatinous and the whole bone or hard part is so covered with spines, which even are to be distinguished in the inner laminæ, that there is sufficient reason for making of it another genus."

There is one point in which Pallas was mistaken, viz., the nature of the ovaries. These he regarded as external chitinous bodies, not always present, which are now known to be parasitic structures.

He says :—" Ovaria, calyces cornea stirpi insidentes, subturbinati," and thought the presence of these calyces to indicate an affinity between *Antipathes* and *Sertularia ;* with this exception, however, the characters of his genus *Antipathes* are remarkably clear and accurate.

Pallas (17) describes ten species in all, one of which, *Antipathes orichalcea*, as he himself suspected, does not belong to the group. Two species are from the Mediterranean, viz., *Antipathes fœniculacea* and *Antipathes dichotoma*, the latter described from a species figured by Marsigli, and of which Pallas had not seen a specimen. The other seven are all from the Indian Ocean, a general term of which it is at present difficult to define the limits. *Antipathes cupressina* is evidently the *Gorgonia abies* of Linnæus, and *Antipathes spiralis* is the *Gorgonia spiralis* of the 10th edition of Linnæus' Systema naturæ, the *Gorgonia abies*, var. *spiralis*, of the 12th edition.

The five remaining species, viz., *Antipathes ericoides*, *Antipathes pennacea*, *Antipathes myriophylla*, *Antipathes flabellum*, and *Antipathes clathrata*, appear to be chiefly founded on types described and often figured in the Herbarium Amboinense of Rumphius. These have not all been identified by subsequent authors, but all apparently conform to the ordinal characters.

Twenty years later Ellis and Solander (19) described six species of *Antipathes*, three already recorded by Pallas, and three new ones, viz., *Antipathes ulex* from Batavia, *Antipathes subpinnata* from the Mediterranean, and *Antipathes alopecuroides* from South Carolina. The latter species, probably owing to imperfect definition and the absence of a figure, has not since been identified, although there appears every probability that it must have been met with in one or other of the American Exploring Expeditions. The same authors give a figure of the polyp of *Antipathes spiralis*, Pallas, or at least of the tentacles and oral cone, the basal portion of the polyp being omitted. The polyp was

shown to have six tentacles arranged in a radiate manner around the mouth. The drawings were made from a dried specimen which was first soaked for some time in water, and imperfect though they are, form the only drawings of the polyp of this species with which I am acquainted. A form described under the same name by Pourtalès is, as will be shown later, generically distinct. The drawings of Ellis brought out for the first time an important point of difference between *Antipathes* and *Gorgonia*, namely, that the polyps of the former have only six instead of eight tentacles. More recently this numerical difference has been shown to be accompanied by important structural differences, but until within the last few years the exact bearing of these points on the systematic position of *Antipathes* has not been understood.

Next in point of time follows Esper (21), who in his beautiful work Die Pflanzenthiere described and figured ten species. This author's descriptions, though long, are often indefinite, but as a rule his figures are good. Three of the species described appear new to science, viz., *Antipathes larix* from the Mediterranean, and *Antipathes virgata* and *Antipathes reticulata*, probably from the East Indies.

Esper's species *Antipathes glaberrima* is the *Savaglia* of Donati and the Italians, and probably forms a considerable part of the "Black Coral" of commerce. In three cases where Esper thought to have obtained species described by Pallas, viz., *Antipathes fæniculacea*, *Antipathes flabellum*, and *Antipathes clathrata*, he describes and figures specimens of decorticated Gorgonidæ and not the true *Antipathes*. All three forms described by Pallas have a spinose sclerenchyma, whereas those described by Esper are all smooth. The same remark applies to his new species *Antipathes ligulata*, which has a smooth axis, and, as first suggested by Dana, is probably a decorticated Gorgonid. *Antipathes compressa*, Esper, is founded on the base of some large species. Dana says that Esper's figure agrees with the base of his *Antipathes arborea*, whilst Gray suggests that Esper's species may be the base of *Antipathes myriophylla*. In any case the name should be dropped, having no specific value, and its retention only adds to the confusion of the group. Esper does not describe *Antipathes ericoides*, but gives a figure of it, and remarks that there are many forms allied to *Antipathes myriophylla*, Pallas, of which *Antipathes ulex*, Ellis and Solander, is one, and *Antipathes ericoides*, Pallas, another. The latter, however, does not seem so closely related to *Antipathes myriophylla* as Esper would have us suppose. Finally his species *Antipathes paniculata* appears to be founded on a variety of *Gorgonia abies*, Linnæus (*Antipathes cupressina*, Pallas), as was first suggested by Lamarck. Dana, however, points out that it differs in the relative development of the lateral branches. There is a fine specimen of this form in the British Museum, which seems to differ from *Antipathes abies* (Linn.) Gray, in possessing stronger lateral paniculate branches, but in other respects agrees with the earlier type; thus, at most, it can only be regarded as a variety.

Bruguière (22) in 1792 gave a synopsis of the species already known, and described

a new one, *Antipathes triquetra*, from Manila. Unfortunately this species is based on specimens which were too imperfect to give specific characters, though they certainly appear to have differed from the species described by Pallas. The species has not been identified by subsequent authors, and is omitted from the work of Milne-Edwards. Its thick triangular stem, with the angles twisted spirally, should make this form easily recognised, even in the absence of particulars of the mode of branching; I am in the meantime, however, obliged to include it amongst the *species dubiæ*.

In 1816 Lamarck (23) described six species of *Antipathes*, but appears to have been particularly unfortunate in his identifications. His *Antipathes mimosella* is probably the same as *Antipathes ulex*, Ellis and Solander, and the latter name has priority. On his own admission, Lamarck's *Antipathes scoparia* is synonymous with Esper's *Antipathes virgata*, whilst *Antipathes pyramidata* is not an *Antipathes* at all, having a smooth and somewhat vitreous axis, and probably comes under Verrill's genus *Iridogorgia*. A fine specimen in the British Museum collection is labelled *Iridogorgia pyramidata*. Lamarck gave the name *Antipathes radians* to Esper's *Antipathes fæniculacea*, which he showed to be different from the true *Antipathes fæniculacea*, Pallas; the species as already stated does not belong to this order. *Antipathes corticata*, Lamarck, is a distinct form figured by Haeckel in his Arabische Korallen, but neither author gives us a detailed description. The remaining species, viz., *Antipathes lacerata* and *Antipathes pectinata*, may be distinct also, but Lamarck's descriptions are very unsatisfactory, and neither form has been identified by subsequent investigators, so that for the present both must be included amongst the *species dubiæ*, the definitions being insufficient for identification.

Lamouroux (24) next added two species to the list, both of which have been accepted by subsequent investigators. It appears probable, however, that his *Antipathes pinnatifida*, which has since been observed by Studer amongst the Corals of the "Gazelle" Expedition, may prove to be a variety of *Antipathes ulex*, Ellis and Solander. There appears to be very great variation amongst specimens of the *Antipathes myriophylla* and *Antipathes ulex* type, and at present it seems difficult to distinguish between those points which are of specific value, and others which only represent individual variations. Owing to the limited number of specimens which I have been able to compare, it has been impossible to decide with certainty, but seeing that no two specimens of this type appear alike, I have preferred temporarily to consider all varieties of one form, for which it seems necessary to retain the name *Antipathes ulex*, Ellis and Solander. In the description of *Antipathes boscii*, Lamouroux makes no reference to the occurrence of spines, a fact which may perhaps have led Gray to include this species in his genus *Leiopathes*. Verrill has more recently described a specimen, which he considers referable to this species; it was obtained by Agassiz off South Carolina, the original habitat. In this specimen the spines are apparently well marked on all parts of the sclerobasic

axis. A small specimen in the University Museum at Copenhagen, which was received through the Museum of Comparative Zoology, agrees with Verrill's description, and is the one on which my description has been based. Lamouroux's description is too indefinite to enable one to decide with certainty whether this specimen agrees with his type.

Lamouroux's Exposition Méthodique (25) contains no new information regarding the Antipathidæ, and so far as that section of the work is concerned, simply reproduces the descriptions and figures from Ellis and Solander's work.

In 1824 he published in the Encyclopédie Méthodique (26) a synopsis of the forms already known. Twenty-six species are described, of which one is new to science. This (*Antipathes eupteridea*) has since been identified by Pourtalès from Martinique, the original locality, and judging from the mode of branching, may possibly prove, when the polyps are better known, to belong to the subfamily Schizopathinæ. At any rate it appears to have a type of branching which so far as is known at present is not found amongst the Antipathinæ. The same work gives a rather fuller description of *Antipathes boscii*, but again no reference is made to the spines. Lamouroux mentions that he has received fragments of this species from the Ile de Ré, off the West Coast of France.

Risso (27), two years later, only recorded one species of *Antipathes* (*A. larix*, Esper) as the result of his researches on the Mediterranean shores of France, but another form which he named *Eunicea Antipathes* may also have belonged to the group, though it appears impossible to decide at present.

In 1832 Gray (28) contributed a note on the Animal of Antipathes, the purport of which will be discussed in connection with a later paper of his on the same subject.

Blainville (31), in his Manuel d'Actinologie (1834–1837), instituted a new genus, *Cirrhipathes*, for the reception of *Antipathes spiralis*, Pallas, and another simple form which he named *Cirrhipathes Sieboldi* (=*Palmijuncus anguinus*, Rumphius?), but of which he gives no description. This genus was proposed by Blainville in consequence of Ellis' observations on the form of the polyp of *Antipathes spiralis*, Pallas, and for the reception of forms which, like it, have an unbranched sclerobasic axis. The systematic value of this genus as defined by Blainville will be considered later when discussing the merits of the classification adopted by Milne-Edwards.

In 1842 Gray (32) proposed to separate those species of Antipathidæ having a smooth sclerobasis, and include them in a new genus *Leiopathes*. The name occurs in the 1842 edition of the Synopsis of the British Museum, but he does not appear to have defined the genus until the publication (40) of his Revision of Axiferous Zoophytes in 1857. In addition to the smooth nature of the axis, Gray calls attention to the presence of spicules in the cœnenchyma, a character which he considered linked this genus more closely to the Gorgonidæ. I propose to refer to the subject again when considering the arrangement suggested by Milne-Edwards.

Dana, in his classic work on the Zoophytes (**34**), gives a short résumé of the species already described by Pallas, Esper, Lamarck, and others, and describes and figures two new species. One of these, *Cirrhipathes anguina* (*Cirripathes Sieboldi*, Blainv. ?), he regarded as the *Palmijuncus anguinus* of Rumphius, and adopts Blainville's name as a synonym. The other form, *Antipathes arborea*, is very closely allied to *Antipathes dichotoma*, Pallas.

Dana was the first to recognise the true relationship of the Antipathidæ and their close affinity to the Actiniaria. On page 574 of his work he says:—The Antipathidæ "like the Gorgonidæ secrete a corneous axis, but are placed amongst the Actinoidea as the tentacles have the naked character peculiar to this suborder, and the polyps closely resemble those of Madreporæ in appearance and habit. The existence of genital lamellæ within the visceral cavity is not yet proved; as this is the deciding character, the propriety of the present arrangement cannot be considered fully established." Dana's work contains figures of both his species with the polyps *in situ*. These bring out several new points tending to remove the Antipathidæ still further from the Gorgonidæ. In the first place, his figures show the undoubted naked character of the tentacles, a feature which may have been presumed from Ellis' drawing of the polyp of *Antipathes spiralis*, Pallas, but which he now placed beyond doubt. It was clear from his figures that the tentacles of *Antipathes*, as well as those of *Cirrhipathes*, are not allied either in number or in form to those of the Gorgonidæ. A further point which seems to have escaped comment, but which, nevertheless, is of considerable importance, is that Dana's figures first brought out a difference in the mode of arrangement of the individual zooids on the axis. In his unbranched species, *Cirrhipathes anguina*, the axis is comparatively stout, and the zooids are distributed all around the stem as in *Juncella* and many Gorgonidæ. In the branched form *Antipathes arborea*, on the other hand, the branches and branchlets are relatively slender, and the zooids are distributed in single longitudinal series, usually with their oral surfaces all turned in one direction. In short, Dana's figures are the first, and for a considerable time remained the only ones, which gave any adequate idea of the appearance of a living colony of an Antipatharian.

In 1849 Jules Haime (**35**), the colleague of Milne-Edwards, described, under the name of *Leiopathes lamarcki*, a form which had previously been confused with *Leiopathes glaberrimā* (Esper).

Gray's second note on the Animal and Bark of Antipathes (**38**) appeared in 1857. In the earlier one already referred to he had described the appearance of the polyps of a form which he believed to be identical with *Antipathes dichotoma*, Pallas. His specimen was sent from Madeira in a dry state, and showed on the minute branches, at irregular intervals, a number of red pellucid tubercles. These on maceration in water proved to be the polyps, provided with six tentacles, but in other respects supposed to agree with those of *Gorgonia*. He also stated that "minute, pellucid, oval bodies, which

are perhaps similar to the irregular papillary spiculæ found in the bark of *Gorgonia*, are scattered through the bark of this species of *Antipathes*, and the axes of its smaller branches are minutely tubular." Gray's observations on the polyp are no advance on the information already supplied by Ellis, excepting that he doubts the existence, in the species studied, of the cup-like oral aperture with a crenate margin figured by that author. I am, however, induced to discuss them at greater length on account of the questionable identity of the species referred to, and also because this form possibly constituted the type of his new genus *Leiopathes*.

In his second paper Gray states that the species formerly observed "has been separated from the others of the genus because the surface of the axis is smooth and not covered with a number of minute, uniform cylindrical spines like the true *Antipathes*, and has been called for that reason *Leiopathes*," evidently referring to his note of 1842 already mentioned. He then goes on to describe the appearance of the "bark" of a long simple-stemmed *Antipathes* from the Seychelles, which he regarded as a new species allied to *Antipathes spiralis*, Pallas, "if more than a very fine straight specimen of that species." The cœnenchyma is stated to contain flakes of a substance insoluble in strong hydrochloric acid or caustic potash, and supposed to be siliceous. This paper is illustrated by a plate, from which I have been enabled to identify the specimen now in the British Museum collection. It apparently belongs to *Cirrhipathes anguina*, Dana, and although dry, shows the same arrangement of polyps (and spines?) as figured by that author. The identity of the species referred to in the earlier paper is not so certain. Undoubtedly it is not *Antipathes dichotoma*, Pallas, as Marsigli, from whose work Pallas took his description, not only notes the presence of spines, but figures their arrangement both near the base of the stem and on a more slender pinnule. I have been unable to find any specimen of *Antipathes dichotoma*, Pallas, in the British Museum collection, but am disposed to think that a specimen of *Antipathes glaberrima*, Esper, the locality for which is not stated, may be the species referred to by Gray. In this species the axis is perfectly smooth and glossy in the older portions of the colony, and the cœnenchyma has been stated sometimes to contain, or rather have adhering to it, the spicules of various Axifera, sponges, &c.

Later in the year Gray (40) contributed to the same journal a Synopsis of Axiferous Zoophytes, in which he included the Antipathidæ. He divides the axiferous zoophytes into three suborders, in the third of which, Ceratophyta, the Antipathidæ form the first family. He describes three genera, *Leiopathes*, *Antipathes* (with a subgenus, *Cirrhipathes*), and *Sarcogorgia*. Under the genus *Leiopathes* he includes two species, viz., *Antipathes glaberrima*, Esper, and *Antipathes boscii*, Lamouroux. The species of which he described the polyps in 1832 and then named *Antipathes dichotoma*, Pallas, he evidently now regards as *Antipathes glaberrima*, Esper, and queries the two as synonymous, and in referring to his original note quotes the name *glaberrima* instead of *dichotoma*.

He makes no comment on the change, which is to be regretted, because it is still doubtful what species he selected as the type of his genus *Leiopathes*. Subsequent authors have accepted *Antipathes glaberrima*, Esper, as the type, and this view seems probable. I am unable to understand on what grounds he included *Antipathes boscii* in the genus *Leiopathes*, the essential character of which is that the axis is smooth instead of spinose. Presumably Gray had seen or thought he had seen a specimen of the species, or it should have been included in the special list, given at the end, of those species which had not come under his notice. It seems highly probable that his words, "Lamouroux's figures represent the bark forming small masses between the branchlets, *as I have observed it on the Madeira specimen*," refer to the supposed *Antipathes dichotoma*, Pallas, rather than to any specimen of the true *Antipathes boscii* which had come under his notice.

Under the genus *Antipathes*, Gray describes eight new species, one (*Antipathes gracilis*) a simple form belonging to the subgenus *Cirrhipathes*, all the others being more or less branched. All his diagnoses are very imperfect, and in nearly every case insufficient for identification. Fortunately the types of these forms, nearly all of which appear distinct, are in the collection of the British Museum, and have thus been accessible for reference. In the section devoted to the description of species, I have added to Gray's original diagnoses such particulars as seem of use in identification. Under the name *Antipathes spinescens* he appears to have included two forms of the "bottle brush" type, which differ considerably in general appearance and may be specifically distinct. For the type not conforming to Gray's description I have suggested the name *Antipathes spinescens*, var. *minor*. A species from Madeira which is referred to *Antipathes subpinnata*, Ellis and Solander, certainly does not belong to that species. Gray seems to have been doubtful on the subject, and admits that his specimen does not agree with Ellis and Solander's figure, and adds, "I had originally described it as distinct under the name of *Antipathes Wollastoni*." I have been unable to find any printed description of *Antipathes wollastoni*, and it does not appear to be described in any of his most numerous papers, a list of which is kept at the British Museum. It may be, however, that Gray only means that he had prepared a description, but that before printing it in the Synopsis under consideration, he decided that it was not a new form. In any case the specimen still bears the name *Antipathes Wollastoni* in Gray's handwriting, and as the species in question is quite distinct from the type of Ellis, I have retained that name for it.

Five other species observed by Gray are referred to: *Antipathes ulex*, Ellis and Solander, *Antipathes myriophylla*, Ellis and Solander, *Antipathes abies* (Linn.), Gray, *Antipathes larix*, Esper, and *Antipathes reticulata*, Esper, respectively. The first four are probably correctly identified, but the last named does not agree with Esper's figure and description. It is very slender, lacks the characteristic short stiff secondary pinnules, and the reticulum is not constructed on the same plan. The apical portions of the colony are free, and the

spines are not nearly so prominent as in Esper's species. The specimen in question forms part of a collection from the West Indies purchased from Scrivener. Another species described from the same collection was named *Antipathes atlantica* by Gray. I find no specimen bearing that name in the collection, but several agree with Gray's characters. All approach his supposed *Antipathes reticulata*, Esper, in form, and a careful comparison has led me to believe that all belong to one species, though there is considerable difference in the relative thickness of the branches. I have therefore retained the name *Antipathes atlantica*, Gray, for these specimens, and include *Antipathes reticulata*, Gray, *non* Esper, as a synonym.

I find no specimen in the British Museum collection bearing the name *Antipathes pluma*, Gray. There are, however, two or three specimens which agree with Gray's characters, one without locality, one from St. Helena, and one more recently received from the East Indies. As the result of a comparison of these specimens with fragments of *Antipathes pennacea*, Pallas, from the Paris Museum, I am led to suppose the two forms to be identical. There is, however, a considerable variation in the length of the pinnules in different specimens; in some, certain pinnules become elongate and pinnate, whilst in others all remain simple. There appears, as far as I could ascertain, no sufficient variation in the spines to afford constant characters. I have therefore regarded Gray's *Antipathes pluma* as synonymous with *Antipathes pennacea*, Pallas.

The genus *Sarcogorgia* must have been included in the Antipathidæ by an oversight, unless Gray regarded *Antipathes* and *Gorgonia* as members of one order, which appears possible. Gray's original description of *Sarcogorgia phidippus* occurs in the Proceedings of the Zoological Society for 1857. Professor E. P. Wright, to whom I have referred in the matter, informs me that he has not seen Gray's specimen, but, judging from the figure, he is of opinion that it may be identical with *Spongioderma verrucosa* (Kölliker), one of the Briareidæ. Gray points out that "some of the smooth species referred to the genus *Antipathes* by Esper, as *Antipathes fæniculacea*, *Antipathes clathrata*, and *Antipathes ligulata*, are evidently the axes of some species of *Gorgoniadæ* that have lost their bark;" he should also have included *Antipathes flabellum*, Esper, in the same category. His definition of the genus *Antipathes* is based on an examination of dry specimens, and it is evident that he failed to grasp the true generic, or, as one might now call them, ordinal characters. He says:—"Bark fleshy, with imbedded, large and small brown (siliceous) plates, easily deciduous. Axis simple or branched, horny, covered with numerous close-set, sub-cylindrical spines." Gray evidently regarded the genus *Antipathes* as closely allied to *Gorgonia*, and as such, probably possessing siliceous plates or spicules within the cœnenchyma. He combats Dana's view that *Antipathes* is nearly allied to the Actiniaria, basing his opposition on his studies of the dried polyps of *Leiopathes glaberrima* and *Cirrhipathes anguina*. He adds, "I am aware that the tentacles do not appear to be pinnated, when they are examined after they have been

dried, but this is the case with the animals of all the Gorgoniadæ I have examined under similar conditions. The pinnæ appear to be permanently withdrawn under such circumstances."

The first volume of Milne-Edwards' Histoire Naturelle des Coralliaires (41), containing an account of the Antipatharia, appeared in the autumn of 1857, so that the author could not have seen Gray's papers on the subject communicated to the Zoological Society in the same year. I am not aware which was published first, but think it probable that this volume may have been issued before the publication of Gray's Synopsis, which occupies the last pages of the 1857 volume. In any case it is unfortunate that two important and independent revisions of the order should have been published in the same year, and that no attempt has since been made to bring their results into harmony. Milne-Edwards, acting on the suggestions of Dana, forms a new suborder of the Zoantharia, Zoantharia sclerobasica or Antipatharia, for this group. He is of opinion that the spinose nature of the axis insisted on by Pallas and others as an essential character, though usual, is not universal, and cannot be regarded as of ordinal value.

Milne-Edwards adopts the genera *Cirrhipathes*, Blainville, and *Leiopathes*, Gray, and proposes to further subdivide the original genus of Pallas, by the establishment of three new genera. A glance at the subjoined table will show the arrangement proposed :—

- Sclerobasic axis
  - simple—rod-like, ... *Cirrhipathes*, Blainville.
  - branched and
    - chitinous; surface of large branches
      - branchlets rough;
        - free, . . *Antipathes* (Pall.) emend.
        - coalescent, and disposed in form of
          - tufts, *Arachnopathes*, n. gen.
          - a fan, *Rhipidipathes*, n. gen.
      - branchlets smooth; cœnenchyma containing siliceous elements, . . *Leiopathes*, Gray.
    - vitreous, ... *Hyalopathes*, n. gen.

Milne-Edwards admits that with the little knowledge then available of the morphology of the Antipathidæ, it would be difficult to establish natural genera with certainty, and the arrangement proposed in the above table is given mainly with a view to aid in the determination of species. It will be seen that the generic name *Antipathes* is retained in a modified sense. Those forms having, or supposed to have, a vitreous sclerenchyma are separated under the name *Hyalopathes*; those having a chitinous axis and showing more or less complete fusions amongst the branches are allocated to two new genera. *Arachnopathes* includes those forms having the branchlets more or less collected into tufts, and *Rhipidipathes* those which, like *A. flabellum*, have a fan-like growth, and have the branches and branchlets confluent. Thus those species which remain to constitute the genus *Antipathes*, *in sensu* Milne-Edwards, may be shortly

described as branched Antipathidæ having a spinose chitinous axis, presenting no fusions between any parts of the corallum.

No new species are recorded, and those previously described are allocated to one or other of the above genera, as best could be done from the descriptions available. With the exception of Duchassaing and Michelotti, subsequent investigators have not followed Milne-Edwards in his subdivision of the genus *Antipathes*, partly on account of the admittedly unsatisfactory state of our knowledge of the group, and partly owing to the fact that it has been generally felt that genera founded on the structure and arrangement of the axis alone could have little value in a natural system. Pourtalès especially has preferred, pending a fuller study of the polyps themselves, to regard the Antipathidæ as consisting of only a single genus, *Antipathes*, those species having a simple axis being included in a subgenus, *Cirrhipathes*.

As no new genera have been proposed since the publication of Milne-Edwards' work, it may be well to consider here the systematic value of the genera therein defined, in the light of the information brought forward in the present monograph. I do not, of course, for a moment suppose that the information which has been obtained concerning the structure of the zooids of some twenty species will prove sufficient for an adequate classification of the group, particularly when it is remembered that we have absolutely no information on the structure of the zooids in the majority of the species described. Still I believe it to be sufficiently complete to be of service in the present instance. In the first place it may be stated generally that although in those forms studied, a similarity in the structure of the zooids is frequently associated with a similarity in the type of branching of the corallum, this is by no means always the case. With regard to the more or less frequent occurrence of fusions between different portions of the corallum, a point which will be discussed in detail later, it may here be stated that the evidence available at present appears to show that such fusions are not constant in all the species of a genus, and are therefore of no generic value. Indeed amongst the species referable to the *Rhipidipathes* type of Milne-Edwards, there are at least three well-marked types of polyp. In other cases where the fusions are slight, and more accurately defined as adherences, the feature is more or less accidental, and probably not even of specific value.

Turning now to the genera adopted by Milne-Edwards, it will be well to consider first those described by Blainville and Gray.

Cirrhipathes, Blainville.—This genus was constituted by Blainville in consequence of Ellis' observations on the polyp of *Antipathes spiralis*, Pallas, and for the reception of those forms in which the sclerobasic axis remains simple. At the time Ellis' figures of the polyps of *Antipathes spiralis* were the only reliable ones extant for any species of *Antipathes*, and further investigation has shown that the form of polyp assigned to this genus by Blainville is, so far as his definition goes, not confined to it, but is shared by

branched as well as unbranched types. Thus, as Milne-Edwards points out, the simple elongate character of the axis is the only feature, in the absence of a fuller knowledge of the polyps, which separates this genus from the other Antipathidæ. This is the character which has been regarded as generic by subsequent investigators. *Antipathes spiralis*, Pallas, constitutes the type of the genus, but unfortunately we have at present no certain knowledge of its polyps, excepting such as may be surmised from the drawings in Ellis and Solander's Zoophytes. These, which only include the mouth and tentacles, appear to represent a rounded polyp with the tentacles arranged in a radiate manner—the form of polyp indeed which one has been accustomed to regard as typical of the Antipathidæ. Whether the polyps were arranged in a single row along the axis as in typical *Antipathes*, or all around the axis as in *Cirrhipathes anguina*, Dana, is uncertain, as Ellis gives no information on the point. An especially interesting feature of the drawings, and one which has given rise to frequent comment, is the curious cup-shaped mouth with a crenate margin, a form of oral aperture which does not appear to be shared by the species subsequently studied by Lacaze Duthiers and G. v. Koch. From a study of allied forms I am inclined to believe that this is a natural feature of the species, somewhat exaggerated, and not an altogether artificial appearance, as some have supposed. At any rate, in *Cirrhipathes propinqua* we have a type of oral cone, which with a little exaggeration (possibly in Ellis' case due to maceration of previously dried specimens) would agree fairly well with the drawings referred to. Pourtalès (71) in 1880 described and figured a species which he regarded as possibly identical with *Antipathes spiralis*, Pallas—a form which he had previously looked upon as a spiral variety of *Cirrhipathes desbonni*, Duchassaing and Michelotti. The polyps as described and figured by Pourtalès are quite unlike those of any species known at the time. The tentacles are long, fleshy, finger-like processes which do not usually shrink much in spirit and are evidently non-retractile. The polyps appear alternately large and small, and are arranged on one side of the stem only. By a comparison of the drawings and description of this form with specimens of *Cirrhipathes spiralis* from the East Indies (the original habitat), I have convinced myself that, irrespective of the structure of the polyps, the two forms are distinct. Pourtalès indeed was doubtful of their identity, but had no means of comparison at the time.

The only other species of *Cirrhipathes* previously described of which any account is given of the polyps is the *Cirrhipathes anguina* of Dana, a form which he regarded as probably identical with *Palmijuncus anguinus*, Rumphius (*Cirrhipathes Sieboldi*, Blainville). This is a species having rounded polyps with radiately arranged tentacles. The polyps are not alternately large and small as in Pourtalès' species, but subequal and disposed all around the axis instead of in linear series. Haeckel has since figured a similar arrangement in *Antipathes corticata*, Lamarck. Between Dana's type and that of Pourtalès there is a marked difference both in structure and arrangement—a difference probably sufficient to be of generic value. The question now arises, does *Antipathes spiralis*,

Pallas, belong to either of these types, and if so to which? Ellis' figure evidently agrees more closely with *Cirrhipathes anguina* than with *Antipathes spiralis*, Pourtalès, the chief difference to be noticed being in the shape of the mouth. In *Cirrhipathes spiralis* (Pallas), the mouth is represented as widely open, and consisting of a cup-like portion with a crenate margin, whereas in *Cirrhipathes anguina*, Dana, the figure shows the mouth contracted and the oral surface only slightly elevated. As previously stated, a new form (*Cirrhipathes propinqua*), which I have been enabled to study, agrees fairly well with the figure in Ellis and Solander's work, and in this species the polyps are distributed all around the stem. The other species included in this genus, those described by Gray, and Duchassaing and Michelotti, have been defined from a study of dry specimens, so that no information is available as to the structure of their polyps.

From this general survey of the question, however, it will be seen that Blainville's chief character for his new genus, the simple filiform character of the corallum, has no generic value, as species having widely different types of polyp may agree in this respect. In subdividing the genus it becomes necessary to retain the name *Cirrhipathes* for that section of it to which the type species, *Cirrhipathes spiralis* (Pallas), belongs. Unfortunately it is impossible to decide the question with certainty at present. The species in question is not found amongst the material collected during the Challenger Expedition, and none of the specimens of it which I have seen are preserved in spirit. From a study of the British Museum collection I have, however, been able to throw a certain amount of light on the question, which, if not sufficient for absolute accuracy, lends a considerable air of probability to the arrangement here adopted. I find that amongst the spiral species in that collection there are one or two specimens in which the polyps are imperfectly preserved. In these cases the zooids appear as rounded elevations on the cœnenchyma, and are distinctly visible all around the stem. The specimens, although more slender than that figured by Ellis, appear to agree with the description, and the fact that they came from the Indian Ocean, makes it still more probable that these are really the *Cirrhipathes spiralis* (Pallas). I have thus been led to include *Cirrhipathes propinqua*, n. sp., *Cirrhipathes anguina*, Dana, and *Cirrhipathes spiralis* (Pallas), in the modified genus *Cirrhipathes*, and to include *Antipathes spiralis*, Pourtalès, and one or two other forms in a new genus, for which the name *Stichopathes* is proposed. Those species of which I have been unable to obtain any information regarding the type, and mode of distribution of the polyps, can only be assigned a proper place when the necessary information is obtained.

Leiopathes.—Gray's definition of this genus (40) is as follows:—"Axis smooth, polished, branched, forked. Bark soft, deciduous, deliquescent, sometimes forming (when dry) smooth transparent masses at the fork of the branchlets." This definition differs in two points from his earlier notes on the type species (28). He omits all reference to the presence of spicules in the cœnenchyma, though whether intentionally or by accident

I am unable to say. His published papers certainly lay stress on the fact that the cœnenchyma of *Antipathes glaberrima*, Esper, which has generally been accepted as his type, contains spicules, and it was not until some years later that Lacaze Duthiers pointed out that these are in reality foreign to it. Milne-Edwards includes this character in the definition given in his work. Gray on the other hand gives in his later definition a character not included in the original, namely, that the "bark" when dry sometimes forms smooth transparent masses at the forks of the branches. In any case this is of minor importance, but so far as I can ascertain, it is characteristic rather of *Antipathes boscii*, Lamarck, than of *Leiopathes glaberrima* (Esper). Gray includes the former species in his new genus, whilst Milne-Edwards does not. I have not seen any specimen in the British Museum which appears referable to *Antipathes boscii*, and for the reason already given I have followed Verrill in regarding it as a spinose species. Milne-Edwards includes three species, viz.:—*Leiopathes lamarcki*, Haime, *Leiopathes glaberrima* (Esper), and *Leiopathes compressa* (Esper); that is to say, all those forms which have been described as possessing a smooth sclerenchyma, but in other respects agreeing with other Antipathidæ. *Leiopathes lamarcki*, Haime, is the *Savaglia* of Donati and the Italians, and is the species which Lacaze Duthiers (44) has shown to differ so essentially from the Antipathidæ that it has been necessary to establish a new family, Savagliidæ (Gerardidæ), for its reception.

Antipathes compressa, Esper, cannot be considered to rank as a species; the type specimen only consisted of the base of some large form, which may or may not have been one of the Antipathidæ. Dana suggests that the base of his *Antipathes arborea* agrees with the figure of *Antipathes compressa*, Esper, whilst Gray compares it to the base of *Antipathes myriophylla*. I think, however, that in this reference Gray does not refer to *Antipathes myriophylla*, Pallas, but to a large virgate species in the British Museum, which also bears that name on the label. There is no resemblance to *Antipathes compressa*, Esper, in any of the specimens of *Antipathes myriophylla*, Pallas, which have come under my notice.

Finally, *Antipathes glaberrima*, Esper, in spite of its name, is not a smooth form, as was first shown by Lacaze Duthiers, and afterwards confirmed by Pourtalès and others. The stem and main branches are smooth and polished, but the younger branchlets all bear distinct though somewhat distant spines. Thus both generic and specific names are misleading, and the genus *Leiopathes, so far as Gray's definition goes*, is not a good one. I have, however, been enabled to study the polyps of *Antipathes glaberrima*, Esper, a species which was included amongst the material kindly supplied to me from the Naples Zoological Station, and I find that this species differs structurally from any with which I am acquainted, and possesses characters sufficiently distinctive to demand its allocation in a separate genus. It thus becomes necessary either to retain the genus *Leiopathes* in an amended form or to establish a new one. As it is very desirable to avoid, wherever

possible, the creation of synonyms I have decided to retain the generic name *Leiopathes* for this species, though I do so with considerable hesitation. In the first place the name has been associated only with such characters as are *not* of generic value, characters indeed which are deceptive or false. Then again, though it is generally accepted that Gray intended *Antipathes glaberrima*, Esper, as the type of his genus, we have no type specimen to refer to, and he is by no means clear on the subject. It is only because *Antipathes glaberrima*, Esper, has the greater portion of the axis smooth, and that its cœnenchyma has been found frequently to have spicules adhering to it, that the species can be made to agree with Gray's definition, and in this respect a dry specimen of *Savaglia lamarcki* would fulfil the conditions equally well. One result of this investigation is to bring out clearly the fact that so far as we know at present there are no species of true Antipathidæ in which the sclerenchyma is entirely without spines, the only species in which the axis is smooth throughout being *Savaglia lamarcki*, and this on morphological grounds has been removed to another family.

Hyalopathes.—This genus was proposed by Milne-Edwards, who gives the following short definition :—"Axe sclérobasique rameux, lisse et d'un aspect vitreux." He was led to separate the forms included in this genus on account of the semi-hyaline aspect of the sclerenchyma, which he supposed to be associated with a difference in chemical composition. Three species are included in the genus, all described by Lamarck, viz.: —*Hyalopathes pyramidata*, *Hyalopathes pectinata*, and *Hyalopathes corticata*. The first named, Milne-Edwards' type, has since proved not to belong to the Antipathidæ, and is now arranged in Verrill's genus *Iridogorgia* as *Iridogorgia pyramidata*. I find a fine specimen in the British Museum collection. The sclerenchyma is semitransparent, smooth, and undoubtedly has a vitreous aspect.

With regard to the second species, *Hyalopathes pectinata*, Lamarck only gives a very imperfect description, and so far as I am aware, it has not been identified by subsequent investigators. I find nothing in his description to give one the idea that the axis differs from the typical chitinous one of *Antipathes*, indeed he does not mention the colour of the axis, as is the case in his description of *Antipathes pyramidata*, but Milne-Edwards may have examined the type specimen. Lamarck describes the spines as few, but if they are present at all the species may belong to the Antipathidæ, although it would scarcely conform to the definition of the genus *Hyalopathes*. With the little information obtainable at present, I have been compelled to include this form amongst the *species dubiæ*.

The third species, *Hyalopathes corticata*, has since been observed by Haeckel, who gives a figure of a living colony in his Arabische Korallen. In the short description which Haeckel gives of this figure, he speaks of the sclerenchyma being black with a glassy aspect and as also being regularly spinose as in the Antipathidæ generally. These researches, though probably not sufficient to enable us to assign to this species its natural

position, at any rate show that it cannot belong to the genus *Hyalopathes* as defined by Milne-Edwards. The axis is not smooth, neither is it semi-hyaline. With regard to the glassy appearance of the black sclerenchyma, it may be stated that this is a character of frequent occurrence amongst the Antipathidæ, and one which has no generic value. The same appearance was noted by Marsigli in his description of the species which we now know as *Antipathes dichotoma*, Pallas. I have also observed it in several species of *Cirrhipathes* and other forms, and, so far as could be ascertained, this aspect is not constant in all the specimens of a species, but appears to depend to some extent on age. So far as can be ascertained from Haeckel's figure and description, this species differs from any other with which I am acquainted in the arrangement of the zooids on the corallum. In other branched forms the zooids are almost invariably arranged in a single linear series on the branches and branchlets. In Haeckel's figure the corallum is represented as very thick in proportion to its length, and the branches do not appear to taper much. The zooids are relatively small, radiate in outline, and not confined to one aspect of a branch. They are a considerable distance apart, and apparently distributed irregularly at any point around the axis. The thickness of the corallum and the shape and arrangement of the zooids recall the characters of the genus *Cirripathes* as modified in the present Report, but the corallum in this species is branched. On account of the fact that we are still ignorant of the structure of the zooids and the arrangement of the spines, I have temporarily included this species amongst a group of others which are too imperfectly known at present to have a definite position assigned to them.

In accordance with this arrangement I propose to drop the generic name *Hyalopathes*, which should be regarded as a synonym of *Iridogorgia*, Verrill. Of the three species comprised in it, the type species is not an Antipatharian; another which does not possess the generic characters is probably closely allied to *Cirrhipathes*, whilst we know too little of the third to assign it any definite position.

The remaining species of the old genus *Antipathes*, Pallas, are divided by Milne-Edwards into three genera, the characters of which depend solely on the mode of branching, and the presence or absence of fusions between adjoining parts of the corallum. He retains the name *Antipathes* for those forms which appear to be without fusions, and divides those in which fusions are frequent into two sections. The name *Arachnopathes* is suggested for those in which the corallum forms a more or less thick confused mass, the branchlets of which are distributed all around the branches, that of *Rhipidipathes* for the flattened fan-like forms, in which the extension of the colony takes place chiefly in one plane.

It has been admitted on all sides that genera of Antipatharia based solely on skeletal structures must be more or less artificial, and Milne-Edwards himself anticipated that further researches would necessitate a modification in his arrangement. Unfortunately we do not yet possess all the information necessary for a proper elucidation of the

group. It will, however, be interesting to ascertain what precise bearing the new facts here brought forward have on the arrangement of Milne-Edwards from two points of view. First it will be instructive to ascertain whether in the light of more recent researches it will be possible to retain the generic names given by Milne-Edwards, and secondly we may arrive at some conclusion as to how far a particular mode of branching appears to be of generic value. For this purpose it appears more convenient to consider the more restricted genera first.

Arachnopathes.—The following is Milne-Edwards' definition of his genus *Arachnopathes*:—"Axe sclérobasique se divisant en une multitude de branches très grêles que se dirigent en divers sens et se soudent entre elles aux points de rencontre, de façon à constituer des réseaux dont la réunion forme une touffe arrondie. Tissu sclérobasique noir et opaque." He includes only two species, viz.:—*Arachnopathes ericoides* (Pallas), and *Arachnopathes clathrata* (Pallas). If I have been correct in my identification of the former species, its mode of branching is precisely that described by Milne-Edwards, and the whole corallum lacks the apparent flatness shown in Esper's plate. A small fragmentary specimen in the British Museum collection may be the *Antipathes clathrata* of Pallas, but if so does not show the marked difference in thickness between the branches and branchlets to which Milne-Edwards refers. This specimen agrees with the former in consisting of a thick dense mass of branchlets all fused into one firm network, but there is not the same marked spiral arrangement of the branchlets as in the former species. A third form here described as new (*Arachnopathes aculeata*) has precisely the same thick matted corallum as the two former species, but in this case the branchlets, although frequently collected into groups, are chiefly confined to one margin of the branches. These three species undoubtedly have a peculiar form of branching in common, and one, too, which is not found in any other described species, so far as I have been able to make out from the frequently scanty descriptions available. The polyps are not known in any of the species, so that whether in this case a particular type of polyp is associated with this peculiar corallum, I am unable to say at present. A much branched type in the Challenger collection (*Antipathella contorta*) is certainly in some respects closely allied to *Arachnopathes clathrata* (Pallas). It shows the same marked contrast between the thickness of the branches and the innumerable needle-like branchlets which spring from them, as is figured by Morison (6). In the Challenger species, however, there appears to be no regular fusion between the slender branchlets in the manner indicated by Morison. The polyps of this species do not appear to differ in any important respect from those of other members of the genus *Antipathella*. I have not seen a specimen which I could with certainty refer to *Arachnopathes clathrata* (Pallas), and, so far as I am aware, it has not been identified by subsequent investigators. A specimen in the British Museum, which agrees fairly well with the original description, does not show such a marked

contrast in thickness between the branches and branchlets as is figured by Morison, and as Pallas refers to this figure, it is to be presumed that his type specimen agreed with it.

The species *Arachnopathes paniculata*, Duchassaing and Michelotti, and *Arachnopathes columnaris*, Duchassaing, referred to the genus *Arachnopathes* by the authors, appear to me to have no place there. The former species, judging from the figure, is a form allied to *Antipathes gracilis*, Gray, and is one of the fan-like species, in which the branches are less confluent than in typical *Rhipidipathes*. *Arachnopathes columnaris*, of which Pourtalès has given us a photograph, has a similar corallum and polyp (?) to *Antipathes larix*, Esper, and has been provisionally referred to *Parantipathes*, n. gen. Fusions occur occasionally between the branches, but it must be remembered that in this type the stem is simple, and therefore the typical *Arachnopathes* form, brought about chiefly by fusion between branchlets belonging to *adjacent branches*, cannot occur. The reticulum to which Duchassaing refers forms a tube for a parasitic worm, and its presence is therefore neither generic nor specific, but depends on the presence of the parasite.

In the systematic portion of this Report I have temporarily retained the name *Arachnopathes* as generic, in order to link together the three species *Arachnopathes ericoides*, *Arachnopathes clathrata*, and *Arachnopathes aculeata*, until more detailed information is obtained regarding them.

Rhipidipathes.—Milne-Edwards gives the following definition of this genus:—"Polypier sclérobasique dont les branches s'étalent sur un même plan en forme d'évantail et se soudent entre elles aux points de contact, de façon à constituer un réseau." At the time only two species had been described which were considered referable to this genus, viz.:—*Antipathes flabellum*, Pallas, and *Antipathes reticulata*, Esper. Gray in a paper published about the same time (40), and other authors more recently, have described quite a number of species which possess in a more or less marked degree the characters referred to. One of the Challenger species (*Aphanipathes cancellata*) shows a closer and more regular network than *Antipathes flabellum*, Pallas. Starting with this species as the one in which the network is most complete, one may trace this character through a number of forms in which it is less and less marked until finally the original feature has entirely disappeared. Such a series might include *A. cancellata*, *A. flabellum*, *A. hypnoides*, *A. reticulata*, *A. gracilis*, *A. paniculata*, D. and M. (*non* Esper), and *A. tristis*. To begin with, the reticulum is formed by bridges of sclerenchyma which pass across from branch to branch, giving a more or less rectangular network, the sides of the meshes being subequal in thickness. In other forms a similar result is obtained by fusion between pinnules of adjacent branches and a general confluence of the stouter portions of the corallum. In *A. hypnoides* one begins to find the terminal pinnate branchlets free, and not showing the fusions so abundant in other parts. From this type onwards in the series there is a gradual increase in the size of the terminal fronds in which fusions do not occur, until in

A. paniculata, D. and M., whole paniculate branches are without adhesions, and the fusion affects only the stem and stronger branches. Finally we have in *A. tristis*, Duchassaing, a type in which actual confluence of parts has ceased to exist, and where, as Pourtalès assures us, the fusions described by Duchassaing are more properly to be considered merely as adherences. It only requires one step further to reach such types as *A. pedata*, Gray, on the one hand, and *A. myriophylla*, Pallas, on the other. Both types are fan-like, the former relatively simple with elongate pinnules, the latter quite as complex as *A. flabellum*, Pallas, but entirely without fusions.

It will thus be seen that the presence of fusions between certain parts of the corallum is not a reliable character for generic purposes.

This fact will be brought out still more prominently if we now consider the structure of the polyps of some of these forms, and enquire whether in any case species not possessing Rhipidipathan characters have a type of polyps found also in that group, and *vice versa*. I have not been able to study the polyps of *Antipathes flabellum*, the only specimens available being dry, as in most of the species referred to. In *Antipathella assimilis*, n. sp., the form of the reticulate corallum is almost identical with that of *Antipathes reticulata*, Esp. The polyp of this species is rounded or oval and is provided with six tentacles, two of which, those at each extremity of the mouth, are usually, though apparently not always, inserted at a lower level than the other four. According to Pourtalès the zooids of *Antipathes tristis* have a similar form and arrangement of the tentacles. This type of polyp is by no means confined to species presenting fusions between different parts of the axis, but is seen typically in *Antipathes subpinnata*, Ellis and Solander, and other laxly pinnate types. *Aphanipathes cancellata*, n. sp., has quite a different form of polyp—a type which Pourtalès has termed sessile. The polyp is oval and so short that it is almost hidden amongst the spines of the sclerenchyma, which often project through the ectoderm in spirit specimens, as is figured by Pourtalès in the case of *Antipathes humilis*. Here again this type of polyp is by no means confined to the species of the genus *Rhipidipathes*, but is common to *Aphanipathes sarothamnoides*, n. sp., and a number of non-reticulate species from the West Indies described by Pourtalès. It is true that in *Rhipidipathes flabellum*, and also in two or three new species which are probably allied to it, the reticulum is formed in a different manner to that of either *Aphanipathes cancellata* or *Antipathella assimilis*, and at present we know nothing of the polyps of these types. Unless, however, they should ultimately prove to have a form of zooid unlike any yet described, the generic name *Rhipidipathes* ceases to have any systematic value. I have not retained it here, because it would be necessary to use it in a restricted sense, and in the absence of further information on the subject it seems advisable so far as possible to refer all species of which the zooids are not known to the genera with which they seem to have most in common.

Antipathes.—Under this genus Milne-Edwards classes all forms of Antipathidæ which have not been assigned a place in other genera. It is needless to say that it includes a medley of species, united only by one common character,—the absence of fusions between adjoining parts of the corallum. So far as the mode of branching is concerned, we find almost every variety from simply pinnate forms, to the most complex. One need only mention *Antipathes pennacea*, Pallas, *Antipathes subpinnata*, Ellis and Solander, *Antipathes larix*, Esper, *Antipathes abies* (Linnæus), *Antipathes myriophylla*, Pallas, *Antipathes dichotoma*, Pallas, and *Antipathes virgata*, Esper, to show the endless variety. At the present time some forty or fifty species might be named, all of which would agree in the plan of branching with one or other of the species enumerated above. Just as the presence of fusions in a colony appears to be of no generic value, so I conceive the absence of them to be a minor feature, of value perhaps for specific purposes (though even then not always), but of no value generically. Of the species which would come under this genus as defined by Milne-Edwards, I find some with dimorphic zooids and others without; whilst in the latter section alone I find amongst the comparatively few species examined at least four distinct types of zooids. Evidently then it is impossible to adopt Milne-Edwards' modification of this genus, and in attempting to found new ones I have relied chiefly on the form and structure of the zooids in the various species observed.

Gray (**42**) in 1860 described two additional species from Madeira, viz., *Antipathes* (*Cirrhipathes*) *setacea* and *Antipathes gracilis*. I have been unable to find the type of *Cirrhipathes setacea* in the British Museum collection, but the type of his var. *occidentalis* is preserved there, and as this appears to differ from any form previously described I have here raised it to the rank of a species.

In the same year the first part of Duchassaing and Michelotti's Memoir on the Corals of the Antilles (**43**) appeared, and in this and the concluding portion published in 1866 four new forms are described, *Cirrhipathes desbonni*, which has since been met with by Pourtalès, and three species of *Antipathes*. Of these *Antipathes americana* is probably a distinct species, whilst *Arachnopathes paniculata* seems closely allied to *Antipathes atlantica*, Gray, and *Antipathes dissecta* is equally closely related to *Antipathes glaberrima*, Esper.

Lacaze Duthiers was the first to study the structure of the polyps of the Antipathidæ, and in 1864 published the first of two important memoirs on the morphology of the group. The earlier memoir (**44**) treats of the structure and relations of *Leiopathes lamarcki*, Haime. The author was enabled to study living specimens collected by the coral fishermen off the coast of Algeria, and for the first time to make out the structure and affinities of the polyp of this form which had not previously been observed. He shows how in different states of preservation the whole or various parts of the colony have received different names.

Lamarck made two species—one of the naked sclerobasic axis (*Antipathes glaberrima*), and another of a specimen covered with cœnenchyma (*Gorgonia tuberculata*). Isolated polyps have been named *Palythoa denudata* and *Zoanthus* sp. The leading points of Lacaze Duthiers' investigation will be found under the genus *Savaglia* (*infra*, p. 51), and I will here only mention those bearing on the systematic position of the species. In the first place this form, for which Lacaze Duthiers creates the new genus *Gerardia*, has not a spinose axis nor does its cœnenchyma contain spicules peculiar to it, but only those which reach it from other forms and become adherent. It thus differs from Antipathidæ in the absence of spines. The sclerenchyma is thin and horny, and is primarily secreted around the axis of some other form, usually one of the Muriceidæ, so that the mode of branching is not characteristic of the *Gerardia*, but of the particular species on which it becomes parasitic. In older specimens where the stems and branches extend beyond the Gorgonid basis, its growth becomes bushy. The polyps have twenty-four tentacles arranged in two rows of twelve each, and each tentacle corresponds to an interseptal chamber as in true Actiniaria. There is also a system of canals in the cœnenchyma, bringing the whole of the polyps of a colony into communication.

In his second memoir Lacaze Duthiers (45) gives an account of the structure of *Antipathes subpinnata* and *Antipathes larix*, which have only six tentacles. Here too he confirms the surmise of Dana, that the Antipathidæ are closely related to the Actiniaria. The mesenteries bearing reproductive organs, which Dana supposed to exist, are described and figured by Lacaze Duthiers from living or fresh specimens. The mesenteries are, however, unequally developed. He describes six: two principal ones bearing reproductive organs placed in a line parallel with the branchlet on which the polyp is placed dividing it into two similar halves, and four others less fully developed and destitute of reproductive organs, two in each lateral portion of the polyp. No sections were made, but so far as could be made out no system of canals in the cœnenchyma similar to those of *Gerardia* are visible externally, though Lacaze Duthiers supposed them to be present.

On account of these researches of Lacaze Duthiers, and the interesting morphological points which they bring out, the Sclerobasic Zoantharia have been divided by Verrill (46) and others into two suborders:—

GERARDIDÆ, with twenty-four tentacles and mesenteries, .	genus *Gerardia*.
ANTIPATHIDÆ, with only six tentacles, . . .	genus *Antipathes*, *&c.*

In 1868 Heller (50) recorded two species as occurring in the Adriatic, viz., *Antipathes subpinnata*, Ellis and Solander, and *Leiopathes glaberrima* (Esper), both forms already known from the Mediterranean.

Verrill, in a review of the Polypi of the East Coast of the United States (48), mentions only two species, *Antipathes boscii*, Lamouroux, collected by Agassiz, near Charleston, and *Antipathes alopecuroides*, Ellis and Solander, the latter on the authority of Ellis.

In another paper on the Halcyonoid Polyps in Yale Museum, Verrill (**52**) describes a new Gorgonid, *Paramuricea cancellata*, founded on a species of Dana's, which he regards as probably equivalent to *Antipathes flabellum*, Esper (*non* Pallas), but in a later part of the same review says that he has a species of *Echinogorgia*, which agrees exactly with Esper's plate of *Antipathes flabellum*. In 1869 the same author described a new species, *Antipathes panamensis*, from Panama Bay.

Pourtalès in a number of papers published between 1867 and 1880, dealing chiefly with the Coral Fauna of the Caribbean Sea and the Gulf of Mexico as explored by the "Hassler" and "Blake" Expeditions, describes altogether eighteen species. Of these eleven are described as new and the remaining seven are referred to Old World types or to forms previously described from the Antilles.

In 1867 and 1868 (**51**) three species were described as new. Two of these, viz., *Antipathes filix* and *Antipathes humilis*, have zooids of a type which Pourtalès terms "sessile." The zooids are very short, so much so that in spirit specimens the spines of the sclerenchyma project through the zooids in all directions. The third species, *Antipathes tetrasticha*, has alternate double rows of branchlets, and small elongate polyps. Two other species are also mentioned and partly defined. These appear in a later paper (**56**) to have been identified as *Antipathes dissecta*, Duchassaing and Michelotti, and *Antipathes lenta*, n. sp., although Pourtalès does not refer to his former descriptions.

In his account of the Corals of the "Hassler" Expedition (**58**) four other species are recorded, two of which are new. Of these, *Antipathes abietina* seems allied to *Antipathes filix*, Pourtalès, whilst *Antipathes Fernandezii* has apparently a similar polyp to *Antipathes tetrasticha*, and perhaps belongs to the same genus.

The other species recorded are *Cirrhipathes desbonni*, Duchassaing and Michelotti, and *Antipathes columnaris* (Duchassaing). It appears, however, from a later paper by the same author (**71**) that the form referred here to *Cirrhipathes desbonni* is a spiral species differing essentially from that type, and was afterwards referred by Pourtalès to *Cirrhipathes spiralis*, Pallas. The second identification appears to me to be equally erroneous, as the polyps in the species referred to are distributed in a single longitudinal series, whereas in *Cirrhipathes spiralis* (Pallas), so far as I can ascertain, they are arranged subspirally all around the axis. The species referred to by Pourtalès, which is particularly abundant in the West Indian Seas, is the one which I have selected as the type of the new genus *Stichopathes*.

The Corals of the "Blake" Expeditions are recorded in two papers. The earlier one (**64**) includes descriptions of two species of Antipathidæ not previously observed by Pourtalès. These were referred to *Antipathes myriophylla*, Pallas, and *Antipathes tristis*, Duchassaing. In the later paper (**71**) Pourtalès corrects an error referring to his identification of *Antipathes myriophylla*, Pallas. It appears that the specimen referred

to this species is really a larger and more densely branched form of *Antipathes filix*, Pourtalès. In this, his last work on the subject, five new species are described, and a sixth, *Antipathes eupteridea*, Lamouroux, was met with apparently for the first time since the species had been described by Lamouroux from a Martinique specimen over fifty years previously. Amongst the new forms described, *Antipathes salix*, *Antipathes rigida*, and *Antipathes thyroides* have a similar polyp to that of *Antipathes humilis*, Pourtalès, and the two former are probably only varieties of the same species. *Antipathes picea* appears to possess a type of polyp not previously described. The oral cone forms a prominent rounded knob, the mouth apparently being very small in spirit specimens, and the tentacles, arranged somewhat in pairs, are flattened and have a crenate margin. Finally, *Antipathes tanacetum* agrees precisely with *Antipathes picea* in the mode of branching, but has much more elongate spines. The polyps in this specimen were too badly preserved to show the arrangement of parts. The true *Cirrhipathes desbonni*, Duchassaing and Michelotti, is also recorded.

Pourtalès is the first and indeed almost the only author who has given us figures of the arrangement of spines in all the species described. His plates also include figures of the polyps of seven species.

In 1871 he advocated the removal of *Gerardia lamarcki* from amongst the Antipatharia, and suggested that it should be included amongst the Zoanthidæ as the type of a new subfamily. He then argued that the polyps of *Gerardia* differ in no particular from those of the Zoanthidæ in the arrangement, number, or shape of the tentacles, and even agree with that group in the habit of encrusting the derm with small foreign bodies. He at the same time pointed out that this genus has no other relationship with the Antipathidæ than the property of secreting a horny axis. He calls attention to the fact that the genera of Antipathidæ as at present defined are based solely on the solid parts, and adds :—

"It has seemed to me, however, that two distinct types of polyps could be distinguished, the one well circumscribed, flower-shaped, symmetrically radiate, with long tentacles ; the other so elongate longitudinally that the radiate shape is quite indistinct, the six tentacles being disposed in pairs at some distance from each other." At the same time he points out that amongst the few species examined there appeared to be no connection between the form of the polyp and the general shape of the corallum.

Throughout all his papers Pourtalès uses the name *Antipathes* as the sole generic designation, but in the last of the series makes an attempt to use the difference in the shape of the polyps, and in the disposition and form of the spines, to draw characters for a revision of the group.

He calls attention to the fact that there are at least two different types of spines, and that these are usually associated with a different form of polyp. In the one type the

spines are cylindrical, generally densely set, and sometimes collected in tufts, as in *Antipathes humilis*. They are frequently unequal on the two sides of the pinnule, being longer on the side occupied by the polyp. In the second type the spines are triangular and compressed. In this case the spines are disposed regularly in quincuncial order around the pinnules, generally, though not always, disposed spirally, and showing no tendency to elongation in the neighbourhood of the polyps. According to Pourtalès' experience those species having triangular spines have polyps with longer tentacles than those in which the spines are cylindrical, and the polyps are usually more regular in shape. "In a very few instances the tentacles are found retracted, as figured by Lacaze Duthiers; in most cases they are simply contracted, and in many species they are probably not retractile at all." Pourtalès was also of opinion that the shape, size, and arrangement of the spines probably afford reliable specific characters. He is indeed the first author who has given us reliable information on these points in the description of new species. Unfortunately Pourtalès was not spared to complete the much needed revision which he contemplated, but the foregoing account of his views on the subject will show that the lines on which he proposed to work are, in the main, those which have been adopted in the present monograph.

Gray in 1868 (**49**) described a new species of *Cirrhipathes* (*C. filiformis*) from Australia, but as in other species described by this author, the polyps were not observed, and the description is insufficient for specific purposes. The type is in the collection of the British Museum, as well as three or four other specimens of the same species collected more recently.

Duchassaing (**54**), in his final review of the Zoophytes and Sponges of the Antilles, describes shortly four new species. Two of these, *Arachnopathes columnaris* and *Rhipidipathes tristis*, have since been observed by Pourtalès, who has figured a specimen of the former, and also the arrangement of the spines in both species. The other species described by Duchassaing, viz., *Antipathes taxiformis* and *Antipathes melancholica*, are very imperfectly described; the latter is probably allied to *Antipathes dissecta*, Duchassaing and Michelotti.

Lütken in 1871 (**55**) described a new form, *Antipathes arctica*, taken from the stomach of a shark captured off the coast of North Greenland. This is the first and only record (with the questionable exception of *Antipathes boscii* already referred to) of the occurrence of any species of Antipathidæ north of the Mediterranean and the southern States of North America. Lütken in a footnote mentions that Sir Wyville Thomson had informed him that specimens referable to this group had been collected during the expeditions for the exploration of the deep water around the British Islands. I am, however, unable to find any reference to them in Sir Wyville Thomson's published works, or in the zoological results of the various expeditions referred to.

Haeckel, in his Arabische Korallen (59), gives a figure of a living colony of *Antipathes corticata*, Lamarck, but unfortunately only gives a few words in explanation of the plate. He also refers to *Gerardia lamarcki*, and copies Lacaze Duthiers' figures. No new species are described.

Klunzinger (60) in 1877 recorded the occurrence of *Cirrhipathes anguina*, Dana, in the Red Sea, and also called attention to another species, *Antipathes isidisplocamos*, first observed in the Red Sea by Ehrenberg. Fragments of the stem are figured, and Klunzinger discusses the probable identity of a specimen, figured as *Antipathes compressa* by Esper, with this species. The specimen is, however, too imperfect to admit of proper identification, and may be the base of any of the larger species already described. It may nevertheless prove to be a distinct species, but in the absence of more detailed information it must temporarily be included amongst the *species dubiæ*.

Studer (65) in 1878 gave notes of two species of Antipathidæ collected during the "Gazelle" Expedition, viz., *Antipathes fœniculum*, Lamarck (? *Antipathes fœniculacea*, Pallas), off West Australia and Mermaid Straits, in 45 to 50 fathoms, and *Antipathes pinnatifida*, Lamouroux, Mermaid Straits, in 50 fathoms. He also mentions the occurrence of broken portions of a large stem, from 900 fathoms, too fragmentary for identification.

G. v. Koch (62), in a paper on the Phylogeny of the Antipatharia, first gives an account of the structure of *Antipathes larix*, and calls attention to the fact that the pinnules arise at right angles to the stem and are disposed in six longitudinal rows. The polyps are placed in a single row on the superior surface of each pinnule, and are elongated in the direction of the pinnules. The mouth is situated on a conical or cylindrical projection from the peristome, and its aperture is usually oval, with the longer axis directed transversely. He describes ten mesenteries in the œsophagus which are unequally developed, only two being complete. These correspond with the long axis of the polyp, and divide it into two symmetrical halves. Four others, not so fully developed, are placed two on each side, so that each chamber corresponds with a tentacle. Four others still more rudimentary "kaum in den Magenraum hereinragende Scheidewände sind so angeordnet, dass sie der Längsachse zunächst stehen." All the mesenteries consist of a thin hyaline layer of connective tissue, which is clothed on both sides by entoderm. In the base of the polyp there is a longitudinal septum having a dilation at its free extremity, in the cavity of which the sclerobasic axis is contained. This is surrounded by an epithelium from which it is derived, and which is probably a portion of the ectoderm.

Koch next describes what he regards as a new genus (*Gephyra*) of Zoantharia, which appears to link closely the Antipatharia with the Actiniaria. The polyps of this species, named *Gephyra dohrnii*, have eighty or more tentacles which can be retracted, as in many Actiniæ and in *Gerardia*. They are found singly or in colonies, parasitic on

the axis of *Isis elongata*, Esper, and other forms, and surround their bases with a black horny mass which becomes separated from a portion of the ectoderm and is homologous with the axial skeleton of Antipatharia. The polyps of a colony are united to each other by basal processes, but have no true cœnenchyma. Koch admits that this species appears at first glance to belong to the true Actiniæ, but believes it to differ on account of the presence of a chitinous base secreted by the polyps, which is not distinguishable from that of the Antipatharia. In his discussion of the phylogenetic relations of the Antipatharia, Koch calls attention to the fact that Lacaze Duthiers first showed their relationship to the Hexacoralla through *Gerardia*, but that on account of the peculiarity of the skeleton of the Antipathidæ, the latter still remained an isolated group. Koch thinks he has added a link in *Gephyra*, which by its skeleton unites the Antipathidæ with the Hexacoralla, and proposes to derive *Antipathes* from skeletonless Hexacoralla similar to the Actiniæ of the present day. The polyps in their anatomical and histological structure are quite like many small Actiniæ, but in *Gephyra* and *Antipathes* there are simplifications, particularly in the musculature, to be attributed to a reduction in the size of the polyps, and their union into colonies. The tentacles for the same reasons have become fewer, but scarcely altered. The mouth and œsophagus show no marked variation in *Gephyra*, *Gerardia*, and *Antipathes*. In *Antipathes* only two mesenteries are fully developed, the remaining eight being more or less rudimentary, but by their position and kind of degeneration we may judge that the ancestor of *Antipathes* had six tentacles and the same number of antimeres. *Gerardia* has twenty-four mesenteries and the same number of tentacles, whilst *Gephyra* approaches the Actiniæ closely in the number of tentacles and mesenteries. *Gerardia* stands alone in having a network of canals uniting the polyps, but *Gephyra* would in this respect approach it more closely were it shown that the colony results from budding.

Koch suggests the following as the most probable stages in the phylogenetic history:—

1. Soft Actiniæ which secrete for their support a horny substance by means of the basal ectoderm.
2. Those situated on a slender cylindrical base surround it and enclose it with horny matter.
3. The polyps, by budding, form a colony. Axis ceases to be solely secreted around some foreign substance, and now grows independently beyond the limits of supporting substance.
4. Degeneration sets in in certain parts.
5. The axis becomes entirely independent. With increase in number, the polyps become reduced in size, and connected with this is a reduction in the number of mesenteries and tentacles.

It may be stated here that *Gephyra*, which has not only been found in the Mediterranean, but also off the N.W. coast of France and off the Irish coast, has been included by Andres amongst the true Actiniaria, as a member of the genus *Sagartia*, as modified in his monograph of the Naples Actiniaria.

Haacke (67) in a review of the morphological relations of the Anthozoa, discusses the position of the Antipatharia from data supplied by the researches of Lacaze Duthiers and v. Koch. As will be shown later, the species on which these observations are chiefly founded, viz., *Antipathes larix*, can scarcely be considered typical of the group. On this account the diagram of Haacke illustrating the arrangement of the mesenteries (sarcosepta) in *Antipathes* is misleading, and as a matter of fact the six mesenteries first described by Lacaze Duthiers, although unequally developed, are all complete in the usual sense in which that term is applied. This subject will be discussed in greater detail when considering the morphology of the group.

Carter in 1880 described (69) under the name *Hydradendrium spinosum*, a species dredged in the Gulf of Manaar, which was supposed to belong to the Hydractiniidæ. The species in question, of which good figures are given, has a branched chitinous axis densely covered with spines. The polyps were not observed. It appears from a later paper by the same author (70) that the Rev. A. M. Norman suggested that the species in question was probably an *Antipathes*, and Carter admits its close resemblance to *Antipathes ulex*, Ellis and Solander. He then discusses the affinities of *Antipathes*, and its probable relation to the Hydractiniidæ. Surely the researches of Lacaze Duthiers in 1866 showed that this could not be the case, whilst v. Koch in 1878 demonstrated that *Antipathes larix*, Esper, possesses all the essential characters of true Zoantharia. The question need not be discussed here further than to state that through the kindness of Mr. Moore of the Liverpool Museum I have been enabled to examine a specimen of Carter's species, which undoubtedly is very closely allied to *Antipathes ulex*, Ellis and Solander. There are, however, certain differences between this form and specimens of *Antipathes ulex* which I have seen, but whether these are of specific value I am unable to decide at present. In the meantime I have regarded Carter's species as distinct.

In the Report on the Challenger Actiniaria (72) R. Hertwig discusses incidentally the phylogenetic relations of the Antipatharia. A new family of Actiniaria is established for certain interesting Actinians, particularly those described by Moseley:—*Actinia abyssicola* and *Actinia gelatinosa*, together with others related to them. The following are the characters:—

Amphianthidæ.—Hexactiniæ, which are attached to the axial skeletons of Gorgonidæ, with shortened sagittal and elongated transverse axis; transverse axis lying parallel to the axial skeleton of the *Gorgonia;* circular muscle mesodermal; the principal septa only are perfect and sterile. In addition to the species included in the Challenger collection, Hertwig supposes the *Actinia s. catherinæ*, Lesson, and *Gephyra dohrnii*, v. Koch,

to belong to the same family. R. Hertwig points out that v. Koch's researches on *Antipathes larix*, Esper, already referred to, show an interesting connection between the form of the polyp in that species and the peculiar elongation of the body in the Amphianthidæ. In *Antipathes larix* "the body is elongated in the direction of the skeletal axis, and the transverse axis of the animal thereby appears lengthened, whilst the sagittal axis is shortened. . . . Two pairs of septa, which correspond to the oral angles, are sterile, and consequently comport themselves like directive septa, whilst the two remaining pairs, lying in the prolonged transverse axis, bear reproductive organs, and are therefore best termed accessory septa." In conclusion he thinks it probable that the Amphianthidæ bring about the transformation of the Actiniaria to the Antipatharia. It is, however, necessary to determine whether the paired arrangement of the septa and the presence of the directive septa can be demonstrated in Antipatharia, and whether the sagittal and transverse axes have the same direction in both groups. The evidence which I have been enabled to obtain on these points will be found in the chapter devoted to morphology.

Andres, in his work on the Actiniaria of the Gulf of Naples (73), discusses the position of *Gephyra dohrnii*, v. Koch, which he places in his genus *Sagartia*, as modified in the monograph in question. G. v. Koch saw in the sclerenchymatous membrane of the base of this species a mode by which the axial skeleton of Antipatharia could be produced, and suggested *Gephyra* as a bridge from the Actiniaria to the Antipatharia. Andres points out that the relation is, so to speak, physiological and not phylogenetic. He calls attention to the similarity in this respect of two deep-sea Actinians described by Moseley, viz.:—*Actinia abyssicola*, found on the stems of *Mopsea*, and *Actinia gelatinosa* on those of *Gorgonia*. At present data are wanting to enable us to decide whether in such cases there is a true morphological affinity or only a parallelism of function. With regard to the systematic value of the power of the "base" to secrete a basal membrane, the following quotation is of interest:—"Forse non lontana parente è la *Phellia nummus* che abita pure acque profonde, secerne abbondante muco solidificabile, ed ha macchie marginali alterne chiare e scure. Il carattere abbracciante (amplectens) della base ha poca importanza; perchè gli animali talora aderiscona a corpi piatti con la base allargata come un'altra attinia qualsiasi."

In 1886 Koch (76) described a new species of *Antipathes* from the Gulf of Guinea (*Antipathes squamosa*), which is allied to *Antipathes spinescens*, Gray, if not identical with it. A new species in the Challenger collection (*Antipathes cylindrica*) has also a similar "bottle-brush" type of corallum.

In a recent review of the results of the cruises of the "Blake," Agassiz (78) refers to the species of Antipatharia described by Pourtalès, calling attention to the frequency and wide bathymetric range of certain forms, such as *Stichopathes pourtalesi* (=*Antipathes spiralis*, Pourtalès) and *Antipathes columnaris*. With reference to the latter species,

Agassiz calls attention to the fact first noted by Pourtalès, that in certain species of Antipathidæ the small twigs on the stem and branches of the corallum may be modified so as to form a tube serving for the protection of parasitic annelids (*Marphysa*, &c.). A similar action of parasitic annelids has been noticed in *Lophohelia*, *Stylaster*, *Allopora*, &c. Agassiz, in an earlier account of certain dredging operations of the "Blake" (66), noticed that the Antipathidæ, like certain Gorgonidæ (especially *Riisea*), showed a bright bluish phosphorescence when coming up in the trawl.

GENERAL MORPHOLOGY.

In the present section I propose to give a general outline of the structure of the various genera of Antipatharia, more especially with regard to the form of the zooid and the number and relative development of the mesenteries. On account of the previous want of information on the subject, it will also be interesting to consider generally the bearing of these preliminary observations on the relationship of the Antipatharia to other Zoantharia.

The Antipatharia are all colonial in habit, and the corallum is usually fixed by a dilated base to some foreign object. Some species are parasitic, and it seems probable that in the ancestors of the Antipatharia this feature was more frequent than in living types. The production of a colony from the original oozooid developed from an ovum has not been studied, but it is probable that this takes place by budding. The colonies consist of blastozooids united together by cœnenchyma, the whole of the soft tissues being supported on a central horny axis. The zooids of the Antipathidæ are all constructed on the same plan, but amongst the genera examined there is a gradual specialisation in one direction, corresponding to a physiological division of labour, and finally resulting in dimorphism.

In an ideal case the zooid is more or less rounded in outline, and consists of a short hollow cylinder projecting beyond the surface of the cœnenchyma for no great distance. The peristome usually bears a central conical projection, on the surface of which the mouth is situated. The tentacles are six in number; they are arranged radially in zooids with a rounded outline, but in many cases there is a more or less well-marked arrangement in longitudinal rows, due to elongation of the zooid in one direction. The body-wall is not separated from the peristome by a well-marked "margin," as in typical Actiniaria, and passes imperceptibly into the cœnenchyma. The oral cone often shows on its inner margin a number of crenate folds, which are partially everted portions of the stomodæum, each fold occupying the space between two mesenteries. In other cases the surface is quite smooth. The mouth leads through a short stomodæum into the cœlenteron. The

stomodæum is supported by a number of mesenteries [1] (sarcosepta) which incompletely divide the cœlenteron into a number of radial chambers. The mouth is rarely round, most frequently it is slit-like, the long axis being placed at right angles to the axis of the branch on which the zooid is situated. The axis corresponding with the elongation of the mouth will be spoken of as the "sagittal" axis, that at right angles to it as "transverse." I have not been able to note any well-marked siphonoglyphe in the various species examined, though, on account of the small size of the zooids, these would be difficult to make out in preserved material, even should they exist.

The tentacles arise from the margin of the peristome, or some form the peristome and others form the body-wall. In the Antipathinæ there are always six tentacles present. These are simple finger-like outgrowths of the cœlenteron. In the Schizopathinæ each zooid bears only two tentacles, but in this subfamily the zooids are dimorphic, and three zooids correspond morphologically with an unspecialised zooid of the ordinary type. In *Dendrobrachia* the tentacles are branched.

The mesenteries, on account of their different relative development, may be conveniently considered under two heads, viz., "primary" and "secondary." This division is, however, artificial, and is merely used for convenience of description.

In all Antipathidæ the primary mesenteries are six in number, and are well developed. The secondary mesenteries are developed in a varying degree in different genera. Of those already examined the number is six or four, or the series may be entirely wanting. The number, arrangement, and comparative length of the mesenteries may be best studied by means of a series of horizontal sections commencing at the oral surface. The number of mesenteries in the oral cone generally differs from that in the lower section of the cœlenteron. The arrangement in the various genera will be best understood by reference to the diagrams.

Leiopathes.

This genus may be conveniently taken first on account of the fact that, as the mesenteries are present in a multiple of 6, it is more directly comparable than other genera with the regular Hexactiniæ. In *Leiopathes glaberrima* the mouth is somewhat elongated in the sagittal axis, whilst the zooid is elongated in the transverse axis. In neither case, however, is the elongation so pronounced as in some other forms.

A horizontal section through the upper portion of the oral cone (fig. 1) shows that

[1] I have used the term *mesentery* in the present Report in preference to *septum* or *sarcoseptum*, because, whatever objection there may be to its use in reference to the Anthozoa, it has within that group a well-defined meaning. It is solely applied to the soft radiating partitions passing from the body-wall to the stomodæum, which imperfectly divide the cœlenteron into chambers. In addition to these in Antipathidæ the individual zooids are imperfectly separated from one another by means of vertical mesogloeal partitions, to which the terms septa and sarcosepta might be considered equally applicable, but which would not come within the meaning of the term *mesentery*.

twelve mesenteries are present, enclosing twelve interseptal chambers of the cœlenteron. In this region the mesenteries are so disposed that an interseptal chamber is situated at each end of the sagittal axis of the mouth, and the middle of each wall of the mouth is also bordered by an interseptal chamber. In other words, both the sagittal and median transverse axes correspond with interseptal chambers instead of mesenteries. The mesenteries are here all equally developed, and consist of a delicate plate of mesoglœa lined on each side by entoderm. Each quadrant of the oral cone contains three mesenteries, two complete interseptal chambers, and half each of a chamber in the sagittal and another in the median tranverse axis. For convenience of description, the mesenteries have been numbered from 1 to 12 in fig. 16, which is diagrammatic. A few sections lower down, the arrangement just described becomes changed. The mesenteries numbered

Fig. 1. Fig. 2. Fig. 3.

FIGS. 1–3.—Horizontal sections of *Leiopathes glaberrima*.

FIG. 1.—Section through the upper portion of the oral prominence, passing also through the two pairs of lateral tentacles.

FIG. 2.—Section near the base of the oral prominence, showing the lumen of each of the four lateral tentacles opening into the circumoral sections of the cœlenteron.

FIG. 3.—Section in a plane beneath the insertion of the sagittal tentacles, showing the six primary mesenteries projecting into the cœlenteron; those in the transverse axis are most important.

4 and 9 in fig. 16 lose their connection with the wall of the oral cone, and become lost, and those numbered 3 and 10 now become gradually more important, and change their position so as to occupy the median transverse axis. This arrangement is represented in fig. 2, which is taken from a horizontal section passing through the base of the lateral tentacles. A little further down four other mesenteries, viz., numbers 2, 5, 8, and 11, lose their connection with the outer wall, and after persisting for a short distance as projections from the wall of the stomodæum, ultimately disappear. In the lower portion of the stomodæum (fig. 3) only six mesenteries remain, namely, those numbered 1, 3, 6, 7, 10, and 12 in fig. 16. These are the mesenteries referred to as "primary." The transverse primary mesenteries are most important, and bear the reproductive organs as well as a well-developed convoluted mesenterial filament. The other primary

mesenteries are somewhat shorter, and on account of the fact that the point where they leave the stomodæum is nearer to the body-wall, have a shorter horizontal course; they bear a rudimentary mesenterial filament, but are devoid of reproductive elements. The section of the cœlenteron corresponding to a tentacle will be seen from the foregoing account to vary in different parts. Two tentacles correspond to the sagittal axis, one being situated at each end of the stomodæum (these are "lateral" as regards the position of the zooids on a pinnule). In these cases the section of the cœlenteron corresponding to a tentacle, that for example between mesenteries 1 and 12, is an enlargement of one of the twelve interseptal chambers present in the oral cone. In the species under consideration these tentacles are usually longer and thicker than the others, and frequently extend horizontally in spirit specimens, whilst the other four stand up vertically. The remaining four tentacles each cover a section of the cœlenteron corresponding to two and a half chambers in the oral cone. When the mesenteries numbered 3 and 10 come to occupy the median transverse axis, one tentacle corresponds to the space between mesenteries 1 and 3, another to that between 3 and 6, and so on.

Cirripathes (*Cirrhipathes*).

In the genus *Cirripathes*, as restricted in the present Report, the zooids are distributed all around the axis, and are never found in single linear series, as in *Stichopathes* and most other Antipathidæ. *Cirripathes propinqua*, n. sp., has been selected as type of the genus, in preference to the older *Cirripathes spiralis*, on account of the fact that it is the only species of which I have been enabled to make a satisfactory examination of the zooids. In this species the zooids are closely packed, more so apparently than in *Cirripathes anguina* and *Cirripathes spiralis*. In spirit they are dull black in colour, have a rounded outline, and the six tentacles are usually arched inwards over the mouth. The greater portion of the peristome projects as a prominent round knob, on the surface of which the mouth opens. The mouth is usually slit-like, and the elongation takes place in the sagittal axis. Sometimes a portion of the stomodæum is somewhat everted, giving the aperture a crenate outline. The oral prominence is usually constricted at the point where it joins the general surface of the peristome, as figured by Ellis and Solander for *Cirripathes spiralis*. If a longitudinal incision be made through the zooids and cœnenchyma, and the whole stripped from the sclerobasic axis, it is seen that the inner surface is traversed by numerous series of irregular rugæ projecting beyond the base of the zooids (Pl. X. fig. 13). The precise relation of the zooids to the sclerenchyma has not yet been made out, on account of the fact that the axis is so thick and brittle that it is difficult to cut sections of it *in situ*. The tentacles are comparatively thick and fusiform, and are arranged in a radiate manner. Those in the

sagittal axis are apparently inserted at a somewhat lower level than the others. In horizontal section the oral prominence is seen to include ten mesenteries, which are subequidistant, but somewhat unequal in breadth (fig. 4). Those situated at each end of the long axis of the mouth are shorter than the others. As in *Leiopathes*, after mesenteries 4 and 9 have been lost (fig. 2), two mesenteries, one on each side, correspond with the transverse axis of the zooid. These are the mesenteries which, lower down, bear the reproductive organs. The stomodæum is folded in such a manner that each mesentery corresponds with a prominence, to which it is attached. The subsequent history of the mesenteries is much the same as that of the corresponding ones in *Leiopathes*. The four mesenteries which are situated two on each side of those occupying the transverse axis,

Fig. 4.

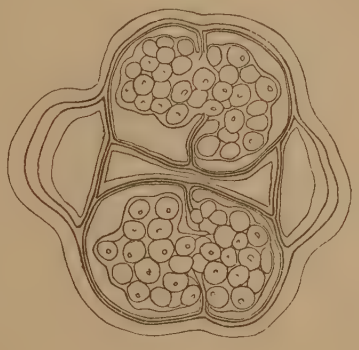

Fig. 5.

FIGS. 4 and 5.—Horizontal sections of *Cirripathes propinqua*, n. sp.

FIG. 4.—Section through the upper portion of the oral cone, passing also through the six tentacles.
FIG. 5.—Section in a plane beneath the insertion of the sagittal tentacles.

lose their connection with the peristome and subsequently become lost. Some time before the base of the stomodæum is reached only the six primary mesenteries remain (fig. 5). In this portion the walls of the stomodæum, in its middle section, are only separated by a slit-like space, but at each end the lumen is large and triangular. The transverse mesenteries are here broadest, and the sections of the cœlenteron on each side of them are almost filled, in the specimen examined, with a dense mass of ova. The two mesenteries at each end of the mouth are relatively thick; each passes from an angle of the stomodæum to the body-wall, which, on account of the great elongation in the stomodæum, is not far away. The sections of the cœlenteron which they include form the lumen of the sagittal tentacles.

Antipathella.

In this genus the shape of the zooid is subject to a variation which has a marked effect on the arrangement of the tentacles. The zooids are usually small and con-

fined to the anterior or superior surface of a branch. In much branched species, in which the stem and main branches are relatively thick, the zooids situated on these portions of the corallum have a rounded outline, with the tentacles radiate and equidistant. The zooid is short and the peristome and tentacles are the only portions of it which project beyond the cœnenchyma. Such zooids are, however, usually not numerous. The majority are situated in single linear series on the medium sized branches, branchlets, and pinnules. In these parts the zooids are somewhat elongated in the transverse axis, so that the long axis of the zooids corresponds with the axis of the branchlet or pinnule on which they are situated. The stomodæum is elongated in the opposite direction, the mouth occupying the sagittal axis. Usually the shape is more or less rectangular, and the difference in length between the sagittal and transverse axes is not great. The elongation is, however, sufficiently important to bring about a change in the position of the tentacles, by which the radial arrangement is lost. In most cases the tentacles become arranged in three pairs, forming two longitudinal rows of three each, parallel to the axis of the branch. There is a tentacle at each end of the sagittal axis as usual. The other pairs consist of a tentacle on each side of the mouth, the two pairs being close together in elongate polyps. These may be spoken of as the lateral pairs of tentacles; they limit the long axis of the zooid. The two pairs of lateral tentacles are always inserted into the peristome. The sagittal tentacles, on the other hand, appear to vary somewhat in position, and arise partly from the body-wall. Thus in a side view of a row of zooids on a pinnule, the middle tentacle of each zooid appears to arise from a point nearer to the axis than the others. In young zooids the bilateral arrangement of the tentacles is often not well marked, and all seem at first to share the radiate outline of those situated on the thicker portions of the corallum. With increase in size a more or less well-marked bilateral arrangement of the tentacles is brought about. In extreme cases the tentacles form two straight rows, one on each side of the median transverse axis. Perhaps with regard to their relations to the axes of the zooid, the rows of tentacles would be more correctly defined as "anterior" and "posterior" instead of longitudinal. It is to be noted that in all the species observed having a zooid referable to this type, the elongation of the body in the transverse axis is not pushed so far as to isolate the tentacles of a row. In most cases they are quite as close together as they would have been if arranged radiately. In transverse vertical sections the mouth is seen to open on a prominent oral cone, from the base of which the ectoderm courses out horizontally for a little distance and then becomes rapidly depressed towards the axis, quickly rising again to commence the outline of the next zooid. In some cases the zooids are more isolated, but are rarely more than one diameter apart. The mesenteries in this genus are ten in number, all of which behave in precisely the same manner as those of *Cirripathes*. The relative breadth of the primary mesenteries necessarily depends on the shape of the zooid and the length of the mouth. The reproductive organs are developed on the transverse

mesenteries as usual, but do not appear to form specialised semilunar thickenings on each side of the mesentery as in *Cirripathes*, nor such isolated organs as those of *Antipathes dichotoma*. The sexual cells are usually imbedded in the tissue of the mesentery.

Antipathes.

In *Antipathes dichotoma* the zooids are very large in comparison with the slender sclerobasic axis which forms their support. The elongation of the zooid in the transverse axis is not very marked, not so much so as it appears at first sight. This is due

Fig. 6.

Fig. 7.

FIGS. 6 and 7.—*Antipathes dichotoma.*

FIG. 6.—Vertical (sagittal) section cutting the sclerobasic axis at right angles, passing to one side of the stomodæum.
FIG. 7.—Subhorizontal section passing on the left, below, on the right, above, the insertion of a sagittal tentacle.

to the fact that whereas the lateral tentacles arise from the peristome, those in the sagittal axis are inserted at a considerably lower level, and there is a deep depression of the ectoderm between them and the oral cone. The stomodæum is elongated in the sagittal axis in its upper section, but is not much folded. Below, its diameter becomes reduced, and there is little difference between the transverse and sagittal dimensions. Ten mesenteries are present in the oral cone, and have a similar arrangement to those of *Cirripathes*. In this portion there is no difference between the primary and secondary mesenteries. A vertical longitudinal section shows that the secondary mesenteries do not extend beyond the oral cone (fig. 6). The section of the cœlenteron corresponding to

a sagittal tentacle is at first very narrow, and the lumen continues slit-like until the insertion of the tentacle is reached. Fig. 7 shows on the right side the slit-like lumen, together with a section of the tentacle, into the base of which it ultimately opens. On the left side, which represents the appearance below the insertion of the sagittal tentacle, the mesenteries are seen to be more important, and the lumen is very large. The reproductive organs are connected with the transverse mesenteries, but the sexual elements are chiefly included in a specialised band of cells, situated obliquely and united to the stomodæum and body-wall by strands of fibrous tissue.

Parantipathes.

This genus appears to form a connecting link between the Antipathinæ and the Schizopathinæ, and indicates a mode by which the dimorphic genera may have been derived from such forms as *Antipathella*, &c. The zooid is enormously elongated in the transverse axis, so that the members of each lateral pair of tentacles are widely separated, and the two near each extremity of a zooid appear to form a pair. The length in the transverse direction is usually four times as great as that in the sagittal. The peristome is somewhat depressed on each side of the oral prominence, so that the zooid is imperfectly divided into three lobes. The whole arrangement is such as might be produced by a great elongation along the sclerobasic axis of such bilateral zooids as frequently occur in the genus *Antipathella*. *Parantipathes larix* is evidently allied to *Antipathella*, and I was at first inclined to regard it as an extreme type of that genus. Besides the most marked elongation of the zooid, in which truly it differs only in degree, there are several other important points in which the species differs from *Antipathella*, so that I have been induced to institute a new genus for its reception. The elongation of the mouth in the sagittal axis is not well marked, and in its lower section the greatest diameter of the stomodæum often corresponds with the transverse axis. This, it will be remembered, is the case in Amphianthidæ amongst the Actiniaria.

Horizontal sections through the middle of the oral cone pass also through the upward dilation of the cœlenteron at each extremity of the zooid, the centre of which is occupied by the distal portion of a transverse mesentery. Around the stomodæum the mesenteries form an oval figure, the longer axis of which is situated transversely. There are here ten mesenteries of varying breadth. The broadest occupy the transverse axis, the others gradually decreasing in size towards the sagittal axis; there is a corresponding diminution in the interseptal lumen. This arrangement is shown in fig. 8. A little lower down, just about the point corresponding with the lowest depression of the peristome, the secondary mesenteries extend as far as the body-wall, but soon lose their connection with it. Fig. 9 represents a subhorizontal section, in which three of the secondary mesenteries have lost their connection with the body-wall, whilst the fourth still adheres to it. The lower

portion of the section passes below the depression in the peristome, the upper portion passing through it. The transverse mesenteries are now seen to be enormously elongated, and to extend the whole length from the stomodæum to the extremity of the zooid. Fig. 10 represents a section at a little lower level, where the secondary mesenteries have become entirely lost. The elongate transverse mesenteries bear the reproductive organs,

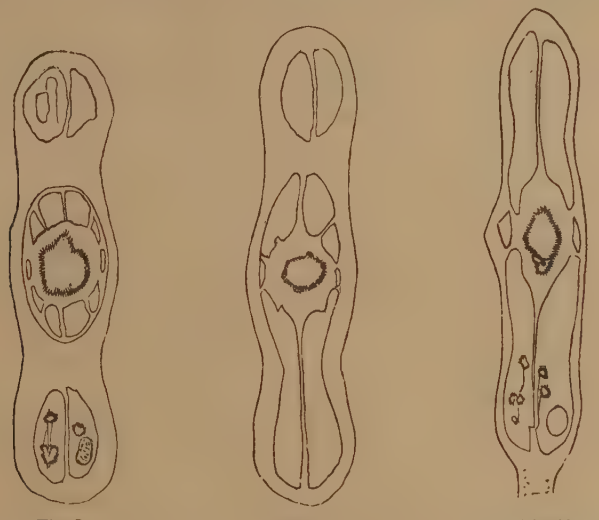

Fig. 8. Fig. 9. Fig. 10.

FIGS. 8, 9, and 10.—Horizontal sections of *Parantipathes larix*. The tentacles are not represented.

FIG. 8.—Section through the upper portion of the oral cone.

FIG. 9.—Subhorizontal section passing through the extreme depression of the peristome in the upper part of the figure, and beneath it in the lower portion.

FIG. 10.—Section in a plane between the insertion of the lateral and of the sagittal tentacles.

chiefly near their distal extremities. For the sake of clearness the tentacles have been omitted in the figures. Those in the sagittal axis open into the central portion of the cœlenteron at a lower level than the section shown in fig. 10. The tentacles in this genus are long and slender, differing considerably from those of *Antipathella*. Lacaze Duthiers and v. Koch have studied the structure of this species; the former made drawings from living specimens.

Aphanipathes.

The zooids in this genus are small, and in many forms are much obscured by the long spines of the axis, which project beyond the surface of the zooid. In all the species examined the zooid is more or less oval in shape, the greater diameter corresponding with the axis of the sclerenchyma. They are somewhat irregularly distributed, not always in a single row, and there is usually a marked interval between the zooids. The tentacles

are evidently very short and project little beyond the surface of the peristome. Usually they appear in spirit specimens as round knob-like elevations arranged biradially around the mouth. The members of each lateral pair of tentacles are separated from each other by the stomodæum, but the two tentacles on each side are usually close together and appear to form a pair as in *Parantipathes* (Pl. III. fig. 9).

All the tentacles arise from the surface of the peristome in this genus, and the oral cone forms a median prominence equalling the tentacles in height. The body-wall usually passes almost immediately from the oral surface around the sclerobasic axis, so that the outline of a zooid is rarely well defined. In specimens in which the sexual elements are well developed the zooid becomes distended, and then its outline is more easily traced. Spines project through the tissues of the zooid in all directions, and in numbers varying with the species. This may be partly due to contraction in spirit specimens, but I have satisfied myself that this feature is not altogether artificial, but is one of the peculiarities of the genus, probably connected with the compressed type of zooid. In horizontal sections spines may be seen projecting through the cœlenteron in many parts. These are usually surrounded by a ring of mesoglœa covered externally by a layer of entoderm. Such an arrangement could not be brought about by shrinking, and I have regarded it as one of the generic characters. The mouth is usually somewhat elongated in the sagittal axis, but in some species (*e.g.*, *Aphanipathes cancellata*) the aperture is usually wide and most frequently circular. In some cases, though rarely, the oral aperture was observed to consist of two terminal circular apertures united by a short median slit-like portion, thus resembling a dumb-bell in shape. Whether in the living colony this may be the usual shape of the mouth, as in many Actiniaria, I am unable to say. Should such prove to be the case, the two terminal rounded openings would probably serve for the entrance and exit of afferent and efferent currents. Unfortunately we as yet know little concerning the living colonies of any of the Antipathidæ. The mesenteries are ten in number, and have the same arrangement as in *Antipathes*. Probably on account of the compressed form of zooid, the secondary mesenteries are in this genus relatively more important, and reach nearly to the base of the cœlenteron. They do not, however, appear to bear convoluted filaments.

Pteropathes.

The single species at present included in this genus differs in several important respects from any other species examined. The zooids form a regular linear series, and are so closely pressed together that the line of demarcation between two adjoining zooids never has a curved outline, but passes straight across the branchlet. Seen from above (Pl. IV. fig. 3) the zooids present a rectangular outline, and the elongation in the transverse axis, when such exists, is not marked. The zooids are imperfectly separated

from each other by a mesoglœal septum, so that on the zooidal surface of the branch there is no tissue which with justice can be considered cœnenchyma. The tentacles are arranged in pairs, those situated at each end of the sagittal axis having an unusual situation. In this genus the zooid appears to clasp the sclerobasic axis to a greater extent than in other genera; thus whilst the lateral pairs of tentacles arise from the peristome, that in the sagittal axis is inserted at a very much lower level, apparently at a point corresponding with the centre of the sclerenchyma. Thus in profile view the ectoderm of the oral cone extends as a relatively flat plate towards the lateral tentacles, but at each end of the long axis of the mouth becomes suddenly depressed and follows the contour of the sclerenchyma to the middle line, and then becomes evoluted to form the sagittal tentacles (Pl. IV. fig. 4).

The zooid is much compressed vertically, though not so much as in *Aphanipathes*. The tentacles are fleshy fusiform processes, but frequently in preserved specimens become much contracted. Those in the sagittal axis appear to be longer and thicker than the others, as is the case in *Leiopathes glaberrima*. There are ten mesenteries present, which have a similar arrangement and relative length to those of *Aphanipathes*, &c. The stomodæum is elongated in the sagittal axis, and the ectoderm clothing its inner wall is thrown into irregular folds. Some little distance below the oral aperture these folds become very complex, and form on each side an elongate branched tubular process, the inner walls of which have the same structure as the inner wall of the stomodæum, with which they are continuous. These convolutions occupy a position which in the main is parallel to the sagittal axis of the zooid, and possess a lumen which opens into the stomodæum.

Schizopathinæ.

The genera forming the subfamily Schizopathinæ differ from all other Antipathidæ in a most important point—the fact that the zooids are dimorphic. The mode in which this dimorphism is brought about will be best understood by a comparison with the arrangement of parts in *Parantipathes larix*. In this species the great elongation of the zooid along the axis of the branch, *i.e.*, in the transverse axis of the zooid, leads to a corresponding increase in the length of the transverse mesenteries. In this, as in all other genera of Antipathidæ, the transverse mesenteries are the only ones which bear reproductive organs. In the Schizopathinæ the elongate zooid becomes divided by two involutions of the peristome into three sections, a central one containing the stomodæum and one at each end in which the reproductive organs are situated. These three sections may remain close together or may become separated from each other by a considerable interval. In reference to their apparent functions, the names *gastrozooid* may be given to the central zooid, and that of *gonozooid* to the one on each side of it. The sequence

of these specialised zooids along a branch is always the same, and may be indicated in the following manner, using the letter R to indicate gonozooid and S the gastrozooid:—

R—S—R—R—S—R—&c. (*cf.* Pl. VIII. fig. 3).

The fission by which the dimorphism is probably produced alters the relation of each zooid to its axis. In both gastrozooid and gonozooid the sagittal axis is longer than the transverse, so that now the long axis of each zooid is at right angles to the axis of the branch instead of being parallel with it. There is no difference in shape between the two types, but the gastrozooid can always be distinguished by the presence of an oral opening in the centre of the peristome; this is usually situated at the summit of a conical or cylindrical projection (Pl. VIII. fig. 3).

Each zooid bears two tentacles, both of which are of the same type, usually fusiform and of considerable length. In specimens in which the ova are well developed the gonozooids become much distended, and are then usually different in colour from the gastrozooids. In *Schizopathes crassa* the gonozooids have a distinct yellow tint, whilst the gastrozooids are a dirty white in spirit preparations. Nearly all the species referred to this subfamily have been obtained at great depths.

Schizopathes.

In this genus the zooids are closely packed, like a number of beads arranged along one surface of the axis. In side view there is scarcely any interval between the individual zooids in normal portions of the colony, and adjoining gonozooids are as close together as each gonozooid is to the gastrozooid to which it morphologically belongs.

In the *gastrozooid* the mouth is situated at the apex of a cylindrical projection of the peristome, which is of considerable length in *Schizopathes crassa*. A series of horizontal sections shows that there is no marked elongation of the stomodæum in the sagittal axis, usually such an elongation does not exist at all. The ectodermal lining is thrown into dendritic folds, and a lumen is rarely visible in the upper portion of the stomodæum. Ten mesenteries are present in the gastrozooid, all of which are of similar breadth in the upper sections of the oral cylinder. These, as in Antipathinæ, are divisible into six primary and four secondary mesenteries; the arrangement is the same as in *Antipathes* and other allied genera. Towards the base of the oral cylinder the secondary mesenteries become lost, apparently remaining attached to the wall of the cylinder after having lost their connection with the stomodæum. The secondary mesenteries in *Schizopathes crassa* all disappear before the plane is reached at which the two tentacles become continuous with the general surface of the peristome. At this point the stomodæum is somewhat elongated in the transverse direction, and the transverse mesenteries being broader than the others the whole oral cylinder is, at its base, oval in outline, its long axis corresponding with that of the branch. Still lower down, where the lumen of each

tentacle opens into the general portion of the cœlenteron, the mesenteries on each side of the sagittal axis become further separated, so as to take up more of a transverse position, on account of the relatively large area of the base of each tentacle.

The *gonozooids* are indistinctly divided into two lobes by a median depression which corresponds in position to a mesentery. The surface of each lobe is continued vertically as a tentacle. Apparently only one mesentery is present in each gonozooid, occupying the transverse axis, and probably to be regarded as homologous with the distal portion of a transverse mesentery in *Parantipathes*. It bears the reproductive organs, which occupy the greater portion of the cavity of the zooid, and also at its base forms a convoluted filament. All the individuals on a branch are in communication with one another by means of a prolongation of their cœlentera, passing from one zooid to another between the base of the filament, or the stomodæum as the case may be, and the tissues surrounding the sclerobasic axis. The individual zooids are separated from one another by incomplete mesoglœal septa passing vertically downwards. They are apparently slightly longer between adjoining gonozooids than between a gonozooid and a gastrozooid (fig. 11). In other words, the individual members of each group of three zooids are not quite so much isolated from each other as they are from the adjoining groups. This difference is, however, slight, and is only noticeable in sections.

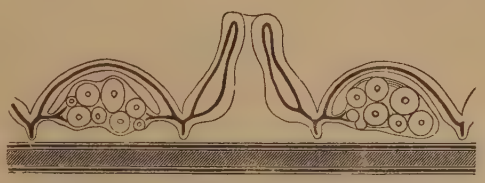

FIG. 11.—Diagram of the arrangement of the dimorphic zooids along the branches in *Schizopathes crassa*.

Bathypathes.

The zooids of this genus do not call for special comment at present. They are similar in outline and in the arrangement of mesenteries to those of *Schizopathes*. The individual zooids are, however, always isolated.

Cladopathes.

This genus is in many respects the most remarkable yet examined. The gastrozooids have an unusually long stomodæum, ending in a funnel-shaped opening close to the base of the zooid. The mesoglœa is very thick, and has a number of connective tissue cells imbedded in its substance. This is the only case with which I am acquainted in which the mesoglœa of the Antipathidæ shows any cellular elements imbedded in its substance. In *Cladopathes plumosa* the stomodæum is much folded, leading apparently to an irregular arrangement of the mesenteries. I have only been able to make out six mesenteries, all of which are "primary," and correspond to the six primary mesenteries of other Antipathidæ. If any "secondary" mesenteries be present

they have no definite arrangement, and I have been unable to find such in horizontal sections. Sometimes what appeared to be an additional mesentery proved to be an apparent confluence of the entoderm of the stomodæum with that of the wall of the oral cone. In such cases I was unable to trace any continuity between the mesoglœa of the two areas. In a series of horizontal sections passing from the mouth to the base of the stomodæum the outline of the latter is most irregular. The mouth is much elongated,

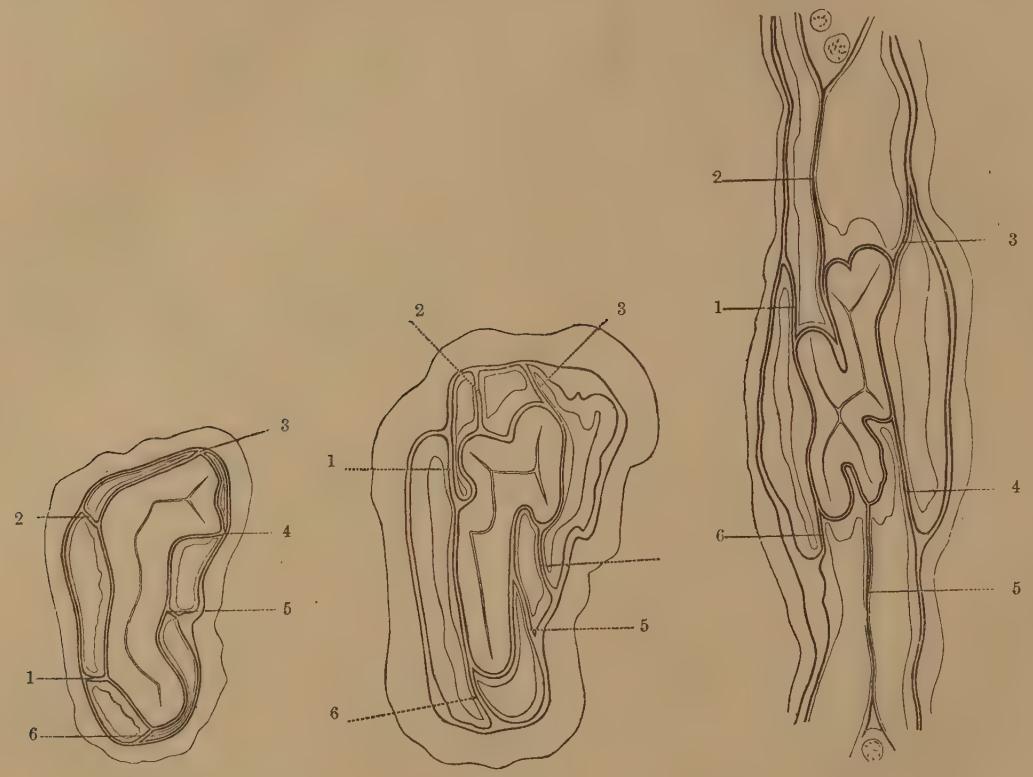

Fig. 12. Fig. 13. Fig. 14.

FIGS. 12, 13, and 14.—Horizontal sections of *Cladopathes plumosa*.

FIG. 12.—Section through the upper part of the oral prominence. The figures indicate the position of the mesenteries. Numbers 2 and 5 are those which ultimately occupy the transverse axis.

FIG. 13.—Section at a lower level than fig. 12, showing the change in position of mesenteries 1 and 4 due to the insertion of the sagittal tentacles.

FIG. 14.—Section near the base of the stomodæum, showing the transverse mesenteries continuous with those of the gonozooids.

but the elongation does not take place in one plane as is usual, nor does it appear that a pair of mesenteries invariably support each extremity as in other Antipathidæ. Fig. 12 shows the arrangement in the upper portion of the stomodæum. The mesenteries are numbered consecutively, following the order of the primary mesenteries in *Leiopathes* (fig. 16). That is to say, numbers 2 and 5 represent the mesenteries situated in the

transverse axis in other genera, and numbers 1–6 and 3–4, those situated at each extremity of the sagittal axis. It will be seen that the elongation of the stomodæum for the greater part of its extent is situated in a plane parallel with that of the sclerenchymatous basis, and that each extremity is turned to the same side. The mesenteries numbered 3 and 4 are normally situated as regards the extremity of the stomodæum to which they are attached, but are situated obliquely in the cœlenteron. Number 6 is, however, displaced from its normal position, which is on the opposite side of the extremity of the stomodæum to that to which it is attached. In other words, there are four mesenteries on one side and only two on the other. This fact is brought out more clearly in fig. 13, which represents the arrangement at a considerably lower level. It will be seen from fig. 13 that the mesenteries in this region have a tendency to become arranged in groups of three, which have a direction somewhat parallel with the horny axis. The mesenteries numbered 6 and 3 are the only ones which retain their primitive position; numbers 4 and 5 have been bent down so as to approach number 6, whilst numbers 1 and 2 have taken up a position nearer to number 3. It will be noticed also that number 1 is now situated much closer to number 2 than in the previous section, and that in consequence the space between numbers 1 and 6 is considerably increased. This section of the cœlenteron opens into the base of a tentacle, as also does that between numbers 3 and 4. Fig. 14 represents a section close to the base of the stomodæum. The stomodæum is here more complexly folded, but its greatest length almost corresponds with the transverse axis—a feature which becomes more and more marked in passing from its upper to its lower extremity. The mesenteries bordering the sagittal axis have now almost reached the position which they usually occupy in other types. The transverse mesenteries are continuous below, with the single mesentery of the gonozooid on each side, which morphologically forms a portion of them. The mesenterial filaments are ribbon-like bands of cells, occupying the base of the cœlentera, and are apparently most prominent in the interzooidal areas and at the base of the gonozooids. Sometimes the cœlenteron of a gonozooid is almost entirely filled with coils of these filaments, the sexual elements being then situated chiefly at the upper extremity, close to the wall of the peristome.

In the specimen examined the gonozooids all bear seminal capsules, varying considerably in number and size in different zooids. The testis appears as a specially differentiated band of cells attached to the walls of the gonozooid by its margin, and is usually separated from the mesenterial filaments in the greater portion of its surface. It has similar relations to those of the ovary in *Antipathes dichotoma*. Judging from a comparison of a number of gonozooids, it appears that the mesenterial filaments become reduced in bulk during active periods of spermatogenesis, so as to make room for the increased size of the testis.

Dendrobrachiidæ.

I am unable to decide definitely the precise systematic position of the genus *Dendrobrachia*, owing to the fact that the polyps are badly preserved. It differs most remarkably from all Antipathidæ in three or four important points, and must be considered as the type of a new family. Like the Antipathidæ it possesses a spinose horny axis, but here the outward resemblance ceases. In transverse section the younger branches show a most exceptional outline. A central canal appears to be absent and the sclerenchyma is arranged in plates radiating from a short central portion (Pl. X. figs. 6–8). A faint line may often be noticed running along the centre of each plate, and the horny matter forming the skeleton is deposited in thin lamellæ as in the Antipathidæ. The free margin of each plate is dentate or spined. The plates seem to be somewhat irregular in their course, which is mainly longitudinal, and vary in number from four to seven. Lower down, the angle between two plates becomes partly filled up with sclerenchyma, and this process goes on until finally a round spinose axis is produced, not distinguishable externally from that of the Antipathidæ.

The zooids are usually very remote and often arranged in pairs, which are sub-opposite, the base of each extending over half the axis. The zooids do not stand out at right angles to the axis as in Antipathidæ generally, but form an acute angle with it, as in many Gorgonidæ. The tentacles, the number of which is uncertain, are not simple fusiform outgrowths of the cœlenteron, but bear a number of relatively elongate branches in all directions. They thus have the dendritic character of the Alcyonaria, and in this respect differ from all Zoantharia, with the exception of the Thallassianthidæ and Sarcophianthidæ amongst the Actiniaria. On this account I was at first inclined to regard *Dendrobrachia* as a genus of Gorgonacea, which approached the Antipathidæ in the form of its axis. There appears, however, to be a total absence of spicules or indeed any skeletal structures, with the exception of the sclerobasic axis, which is horny throughout, and deposited in thin lamellæ, as in the Antipathidæ. Another feature in which *Dendrobrachia* differs from the Antipathidæ is to be found in the fact that in retraction the tentacles may be completely covered by the anterior portion of the body-wall. The fact that nearly every zooid observed was in this condition has tended not a little to prevent a satisfactory examination of their structure. Frequent attempts have been made to ascertain the number and arrangement of the mesenteries by means of horizontal sections, but I have, so far, been unable to arrive at any definite conclusion. In some cases I thought I recognised ten mesenteries, in others eight, and in others again only six. I also failed to recognise any well-marked band of muscular fibres on either side of a mesentery. This genus therefore appears to approach the Gorgonidæ more nearly than any other known Antipatharian, and possesses a curious medley of

characters, which when fully investigated will undoubtedly prove of great interest. The exceptional mode in which the ultimately round and densely spinose horny axis is produced is especially worthy of note.

Savagliidæ (= Gerardiidæ).

The single species constituting the genus *Savaglia*, Nardo (*Gerardia*, Lacaze Duthiers), was separated by Lacaze Duthiers in 1864 from the Antipathidæ on account of the structure of the polyps, which very closely resemble those of Hexactiniæ. His observations refer to living specimens, and bring out many points showing the most interesting relations of the genus. The following is a summary of his results :—

The sclerenchyma in fresh specimens has a bronzed coppery black colour; when dry it is jet-black. The mode of branching in young colonies, which are always parasitic, varies with the species of Gorgonidæ, which acts as its support; usually the branches extend in one plane without touching or fusing. Later, with greater development, bridges are often thrown across from one branch to another, and fusions take place without regularity. These fusions are produced by fractures or abrasions, and cannot be considered characteristic of the species. Lacaze Duthiers points out that it was want of knowledge on this point which led Haime to consider the mode of branching as a specific character. The base is often very large, sometimes "as thick as a man's leg," whilst the branches are only 1 to 2 dcm. long. This is an abnormal growth due to the constant working of the coral fishers over the ground, by which the branches are repeatedly broken off. Specimens which have been allowed to grow undisturbed, such as were brought to Lacaze Duthiers from a bank not previously worked, are very large, fine, and much branched, without such a great base. In such cases, where the sclerenchyma extends beyond the Gorgonid basis, the growth becomes bushy. Very old specimens frequently have a number of anastomosing branches, sometimes descending from a superior part to fuse with one below, at others very long branches may unite with those of the opposite side of the sclerobasis and form transverse connections, the origin of which is due to a primary fracture and subsequent fusion. The branches are not cylindrical, but flattened on one side, along which there is a well-marked groove. The branchlets are usually swollen at the tip, and are never thread-like or pointed as in the Gorgonidæ. Tubercles often occur on the sclerobasis, which indicate the point of origin of new branches, or the bases of broken ones. Under a low magnifying power the sclerobasis is seen to be covered with very small mammiform tubercles, with a depression in the centre. Lacaze Duthiers describes one specimen parasitic on a grey, flexible, striated axis, undoubtedly that of *Muricea placomus*. In this specimen the zoanthodema consisted solely of sarcosome on a borrowed axis, and no sclerenchyma had as yet been deposited. In another specimen of the same Gorgonid two or three patches of *Gerardia* were present on the

apical and secondary branches, which on examination were seen to have secreted a delicate horny sheath around the Gorgonid. The filamentous prolongations of the egg-capsule of Dog-fishes and Skate may be similarly invaded by the soft *Gerardia*, which later extends over the various filaments and secretes a chitinous sheath around them. These specimens, several of which are figured by Lacaze Duthiers, show clearly how a transition may have taken place from the malacodermatous to the sclerobasic type.

The polyps vary considerably in size, but are as well developed at the tips of the branches as at the base. They may be 1 cm. in diameter at the base and may elongate to 2 or 3 cm., while the tentacles reach a similar length in downwardly directed polyps. On the other hand, the whole polyp may so far contract as to form a mammiform tubercle on the sarcosome. The base of each polyp is irregularly polygonal. In various places buds are present, which give rise to new polyps,—these are less frequent on the main trunks, where the polyhedral character of the base is best seen.

The tentacles are twenty-four in number, and are arranged in two alternate rows of twelve each, the members of one row being slightly larger in living specimens. The mouth is oval and is surrounded by two thickened lips, which are an everted portion of the stomodæum. The mesenteries, twenty-four in number, bear reproductive organs as in the Actiniaria, and have at the free margin a thickened convoluted ridge occupying one-quarter of its length.

The cœnenchyma is unimportant in bulk, there being only a narrow strip between adjoining polyps. It has, however, a structure which, so far as is known, is peculiar to the family. It is traversed by a series of canals communicating with the polyps at the base of each antimere, and by this means bringing all the blastozooids of a colony into intimate communication with one another. *Cirripathes*, amongst the Antipathidæ, appears to approach this genus most closely in the structure of its cœnenchyma. The colour of the soft parts is greenish yellow, but near the reproductive season the polyps become brick-red.

The spicules, &c., sometimes contained in the cœnenchyma are those of Pennatulidæ, Corals, Gorgonidæ, Sponges, Foraminifera, &c., all of which become agglutinated to the viscous ectoderm, but none are peculiar to it.

The Homologies of the Mesenteries.

In the foregoing account of the general structure of the zooids of the various genera of Antipatharia I have purposely avoided any reference to a possible arrangement of the mesenteries in pairs, and the term "interseptal" has been applied to the space between any two mesenteries, and not in its technical and restricted sense as applied to Zoantharia generally. I have followed this course because the usual paired arrangement is not marked in any of the species examined, unless it be in the mesenteries situated at each

end of the long axis of the stomodæum. It now becomes necessary to enquire whether the mesenteries of Antipathidæ may not be arranged in pairs, and whether, if this be the case, the arrangement corresponds with that in other Zoantharia. In the Hexactiniæ all the mesenteries are usually supposed to be arranged in pairs, which consist of adjoining mesenteries. The section of the cœlenteron situate between a pair of mesenteries is termed "intraseptal," that between adjoining pairs "interseptal." Two pairs are known as "directives;" these are situated in the sagittal axis, and usually terminate the long axis of the mouth. On these the retractor muscles occupy the interseptal surfaces; in all other cases, the intraseptal. Thus the position of the retractor muscles enables one to determine the paired arrangement of the mesenteries, and also to decide which are to be considered "directives." Unfortunately in nearly all the Antipathidæ the muscular system is so feebly developed that I have not yet been able to make out any special collection of muscular fibres on either side of a mesentery. On account of the extremely small size of the zooids of most species, the mesenteries are rarely well developed, and even in such species as *Parantipathes larix*, where those in the transverse axis are much elongated, there appears no corresponding increase in the importance of their musculature. Thus the sure guide to the paired arrangement in many other Zoantharia is not available here. In this connection it should, however, be remembered that in the Cerianthidæ there are apparently no retractor muscles, and the protractors are very feebly developed, added to which the mesenteries are not arranged in pairs on the Hexactinian plan. In the Zoanthidæ also the musculature is more rudimentary than in Hexactiniæ.

Undoubtedly, the fact that there are twelve mesenteries and six tentacles in *Leiopathes* would seem to indicate, on *a priori* grounds, a paired arrangement of the mesenteries. This seems the more probable when it is remembered that, in all other genera of Antipathidæ of which the zooids are known, there are either ten or six mesenteries, and that in both cases the number might be regarded as directly derivable from the arrangement in *Leiopathes*. If the twelve mesenteries found in *Leiopathes* are to be interpreted according to the usual arrangement in Actiniaria and Madreporaria, *i.e.*, on the Hexactinian basis, it is necessary that the mesenteries numbered 1 and 12 (fig. 16) should form a pair, as also should numbers 6 and 7. These must then be considered the two pairs of "directives." In this case numbers 2–3, and 4–5 form pairs, and there is a similar paired arrangement on the opposite side of the stomodæum. The effect of this arrangement would be that, of six pairs present in the upper portion of the oral cone, two, the directives, remain intact, two are lost entirely, and the other two pairs become reduced in the lower section of the cœlenteron to a single member each. In this case the sagittal tentacles correspond to intraseptal spaces. The arrangement of the tentacles on each side of the transverse axis is really not the same. Mesenteries 3 and 10 are the two which ultimately occupy the transverse axis, and the tentacles to the

left correspond to an inter- and an intraseptal space, whilst those to the right correspond to an intraseptal and two interseptal spaces. In order to explain the ultimate arrangement on this plan, it would be necessary to suppose that a fusion takes place between the two median transverse mesenteries, and that the interseptal space between them is thus lost. There does not, however, appear to be any evidence in favour of this view. It would also be difficult to understand the extremely rudimentary character of two pairs out of the six, the tentacles corresponding to them being quite normal. Perhaps v. Koch's theory of degeneration might suggest an explanation, but there does not at present appear to be sufficient evidence in its favour. Again, the tentacles may be presumed to have originally corresponded to intraseptal chambers, and those in the sagittal axis still continue to do so on this view. It may further be supposed that by an imperfect development of one member of a pair in other parts, the tentacles come to correspond below with a wider section of the cœlenteron. An elongation of the body in the transverse axis should then cause an increase in the size of the interseptal spaces, so that mesentery 2 would become removed further from mesentery 1, and so on. Such, however, does not appear to be the case. In *Leiopathes* and several other forms, mesenteries 1 and 2, 5 and 6, 7 and 8, and 11 and 12 remain relatively close to one another so long as the "secondary" members of each couplet are present (*cf.* fig. 2). The close relation between mesenteries 3–4 and 9–10 respectively is also very interesting. If one traces the course of these mesenteries from above downwards, their mutual relationship is well seen. For instance, number 3 approaches the transverse axis and becomes more important in proportion as its fellow becomes reduced.

An alternative explanation of the arrangement of mesenteries in *Leiopathes* may now be mentioned, if only in order to exhaust the possible arrangements in pairs consisting of *adjacent* mesenteries. I refer to the possibility of the mesenteries on each side of the median transverse axis forming a pair. On this basis the mesenteries numbered 1–2, 3–4, 5–6, &c., would form pairs, in which case each pair would consist of a primary well-developed mesentery and a secondary imperfect one. There would then be no pairs of "directives" corresponding to those of other Anthozoa, which seems a great difficulty. Although I do not consider this a probable explanation of the arrangement in Antipathidæ, a consideration of its bearings brings out an interesting point. The pairs would be situated one on each side of the sagittal axis at each extremity of the mouth, and a pair in the transverse axis on each side of the mouth. The reduction in the number of mesenteries affects one member of every pair, but those are first to disappear which are situated in the transverse axis. A glance at fig. 16 will show the effect of this arrangement; the primary mesenteries are indicated in thicker outline. The bilateral arrangement, on such an interpretation, is peculiar. Supposing mesenteries 1 and 12 to occupy the "anterior" extremity, the mesenteries which are incompletely developed are the *posterior* members of the first and second pairs on each

side, and the *anterior* members of the two "posterior" pairs. This arrangement, disregarding for the moment the want of directives, is not without parallel amongst the Actiniaria. G. v. Koch, R. Hertwig, and Erdmann have shown that in the Zoanthidæ there is an alternation of macro- and microsepta, which is regular, excepting as regards four pairs. The majority of the pairs of mesenteries consist of a macroseptum and a microseptum, *i.e.*, of one which is complete and another which is incomplete. The macrosepta bear reproductive organs and mesenterial filaments; the microsepta are sterile and end on the oral disc. In the sagittal axis one pair ("ventral") consists of two macrosepta, and corresponds with the single siphonoglyphe. The other pair of "directives" consists of two microsepta. In addition to the directives two other pairs consist of mesenteries of the same type. These are usually situated one on each side, and only a little distance from the small ("dorsal") directives. They may consist of either micro- or macrosepta. Erdmann explains this peculiar arrangement by supposing that a dorsal and ventral zone of mesenteries exists, and that the two zones approximate either with small (*microtype*) or large mesenteries (*macrotype*). According to his investigation, the approach of the two zones is brought about by two mesenteries of the microtype in *Zoanthus*, *Mammilifera* and *Corticifera*. The macrotype arrangement is found in *Epizoanthus* and *Palythoa*. The microsepta appear to be rudimentary and not young ones, and supposing them to correspond with the imperfect mesenteries of *Leiopathes*, there would be a similarity in plan between the arrangement in *Leiopathes* and those Zoanthidæ having the mesenteries arranged on the microtype.[1] According to this view, the tentacles in *Leiopathes* correspond in the main to interseptal chambers. The intraseptal space between the two pairs of mesenteries in the transverse axis is lost, whilst the other intraseptal areas, in elongate forms, abut on a portion of the lateral body-wall.

An apparently fatal objection to this explanation consists in the fact that the arrangement of mesenteries in Antipathidæ would have no parallel in the Actiniaria or Madreporaria. In these orders the sagittal axis is terminated at each extremity by a pair of "directive" mesenteries and not by two adjoining members of adjacent pairs. The probable absence of a siphonoglyphe may mask the arrangement of mesenteries, and the greatest diameter of the oral aperture may possibly not lie in the true sagittal axis. It may be mentioned that a flattening of the stomodæum at one, or sometimes at both extremities, has been observed in certain species (*e.g.*, *Cirripathes propinqua*), but I am unable at present to determine its significance. Apparently there is no structural difference between this and other portions of the stomodæum.

A comparison of the arrangement and comparative development of the mesenteries in *Madrepora*, *Seriatopora*, and *Leiopathes* is of considerable interest. Figures 15, 16, and 17 represent diagrammatically the arrangement of mesenteries in the three genera.

[1] A different interpretation of the arrangement of the mesenteries in Zoanthidæ is suggested on p. 59.

The thick lines indicate those mesenteries which are well developed in the respective genera, the thin lines those which are not so important. It will be seen that in *Madrepora durvillei* (fig. 15) and *Seriatopora* (fig. 17) six mesenteries are well developed, but that according to Fowler the arrangement in the one genus is precisely the reverse of that in the other. In *Madrepora* numbers 2, 4, 6, 7, 9, and 11 represent the strongly developed mesenteries, and of these numbers 4 and 9 extend lower down into the cœlenteron than the other four, and are the only ones which bear reproductive organs. In *Seriatopora*, numbers 3 and 10 are the longest. The reproductive organs were not observed in this genus, but in *Pocillopora*, which has the same arrangement without such a distinct division into three series of different lengths, apparently all the mesenteries may bear reproductive organs. In *Leiopathes* (fig. 16) I have not ascertained which is the "axial" and which the "abaxial" extremity of the stomodæum, possibly the reverse of the arrangement shown, but for my present purposes it is not important. Here the

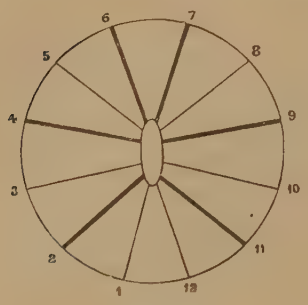

Fig. 15.

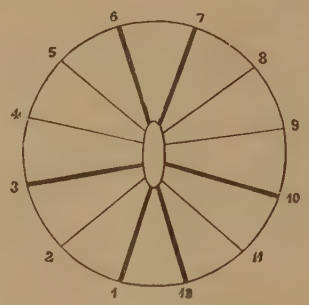

Fig. 16.

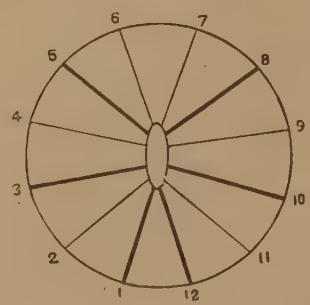

Fig. 17.

Fig. 15.—Diagram of the arrangement of mesenteries in *Madrepora durvillei*. Nos. 6 and 7 are the axial, Nos. 1 and 12 the abaxial directives.

Fig. 16.—Diagram of the arrangement of mesenteries in *Leiopathes glaberrima*. The thicker lines indicate the primary mesenteries.

Fig. 17.—Diagram of the arrangement of mesenteries in *Seriatopora*. Nos. 6 and 7 are the axial, Nos. 1 and 12 the abaxial directives.

mesenteries numbered 1, 6, 7, 12 and 3, 10 (or 4, 9) are the primary ones. Of these 3 and 10, as in *Seriatopora* (or 4 and 9 (?) as in *Madrepora*), are the longest, and are the only ones which bear reproductive organs. The four mesenteries numbered 3, 4, 9, 10 are precisely those which show an inter-relationship. One pair remains as the transverse mesenteries, the others are the earliest to disappear. A very short way down the oral cone the four have become reduced to two. Thus if we suppose a combination of figures 15 and 17, accompanied by a replacement of the two pairs of mesenteries bordering the transverse axis by one pair situated in the transverse axis, we get precisely the arrangement of primary mesenteries in the Antipathidæ. This does not necessarily imply a close phylogenetic relation, but is interesting as showing a similar behaviour of mesenteries 3, 4, 9, and 10 in Antipathidæ and certain Madreporaria.

It appears to me, however, that neither of the foregoing explanations gives a clue to the real arrangement of mesenteries in Antipathidæ, and I now propose to indicate in outline my own views on the subject, which appear not only to meet the case, but also to throw considerable light on the homologies of the mesenteries in the Anthozoa generally.

The arrangement of the mesenteries in pairs consisting of adjacent members, as found in adult Hexactiniæ, does not necessarily imply that the members of a pair when at first developed all bore the same relation to one another as they do ultimately. This we know from the researches of Lacaze Duthiers, Kowalevsky, and the brothers Hertwig on various types. Unfortunately the order of development of the first six pairs of mesenteries is not thoroughly understood, and the various investigators give somewhat different accounts. One point, however, appears clear, and that is that the earliest formed mesenteries are not developed on precisely the same plan as those which appear subsequently. After the first twelve mesenteries have been formed, four of them situated two at each end of the long axis of the stomodæum become the pairs of "directives," and have the retractor muscles on the intraseptal surfaces; the other eight are arranged in so-called "pairs," having the retractor muscles on their interseptal surfaces. It is, however, to be noted that the two mesenteries forming each pair of "directives" were in point of time developed together and embryologically form true pairs. The other four pairs each consist, on the other hand, of mesenteries which are not of the same age, and therefore do not come under the same category. This is clearly seen from Hertwig's figures of *Peachia*. The first twelve mesenteries arise from single rudiments and developmentally form pairs, the members of which are on opposite sides of the stomodæum. Owing to the development of the retractor muscles on adjoining surfaces of the couplets along the lateral walls of the stomodæum, each couplet, consisting of mesenteries of different ages, comes to be regarded as a "pair." After this stage the further addition of mesenteries in Hexactiniæ takes place in a different manner. Buds appear on the body-wall in the interseptal spaces and opposite to one another as before, but in this case each bud gives rise to two mesenteries, having the retractor muscles on their adjoining surfaces. In this way the majority of the mesenteries in Hexactiniæ are formed, and it will be seen that these "pairs," like the "directives," consist of mesenteries of the same age, but that unlike them the members of a "pair" in this case were formed as adjacent and not as opposite mesenteries. Perhaps two opposite pairs of this type should be considered analogous to one pair of the primary mesenteries. Whatever number may ultimately be present, the new pairs are always added in the lateral sections of the cœlenteron, and the original "directives" are never separated, but, on the other hand, tend to become more closely pressed together. As already stated, previous authors are not agreed as to the order in which the first twelve mesenteries (six "pairs") are developed, and so far as the Actiniaria are concerned, I do not at present propose to discuss the matter further.

If, however, the researches of Lacaze Duthiers should be confirmed, it appears to me that there is an important connection between the order in which the first twelve mesenteries are developed in *Actinia*, *Heliactis*, &c., and their relative importance in Antipatharia, a connection which may probably throw light on the phylogenetic relations of the two orders. If I have understood Lacaze Duthiers aright, the first twelve mesenteries in *Actinia*, &c., are developed in an order which may be explained by a reference to fig. 16. The first to be developed are numbers 3 and 10 of that figure, the second, numbers 6 and 7, the third, numbers 1 and 12, the fourth, numbers 5 and 8, the fifth (?), numbers 2 and 11, the sixth (?), numbers 4 and 9. Lacaze Duthiers does not number the mesenteries in the same order in his figures of *Actinia* as in those of *Heliactis* (*Sagartia*). Now if the order which I have indicated should prove to be the correct one, it precisely corresponds with the relative development of the mesenteries in *Leiopathes* and other Antipathidæ. Numbers 3 and 10 are in *Leiopathes* the longest, numbers 1, 6, 7, 12 next; numbers 2, 5, 8, and 11 come next; and finally, numbers 4 and 9 are the shortest of all. It is to be noted further that each of these pairs of mesenteries are stated by Lacaze Duthiers to be developed synchronously. One might suggest that on the formation of the mesenteries numbered 1, 3, 6, 7, 10, and 12, the cœlenteron is divided into six chambers, one anterior and one posterior, both of which are limited by the directive mesenteries, and four lateral chambers, two on each side of the stomodæum. At this time evidently the mesenteries which divide the lateral sections into two form a pair. The two lateral chambers become further subdivided by pairs of mesenteries which developmentally are not adjacent mesenteries, but situated on opposite sides of the stomodæum. In this way the lateral chambers become increased from two to five on each side. On such an interpretation the arrangement is bilateral, and consists of an anterior and a posterior chamber, together with five pairs of lateral ones. The anterior and posterior pairs of mesenteries consist of two adjoining members, all the others of two opposite members, that is to say, one on each side of the stomodæum. The directives come to be adjacent mesenteries, because no others are added between them. On this hypothesis it is necessary to suppose that in Actiniaria this primitive type of bilateralism has become modified in various ways according to the family. The bearing will be sufficiently evident without further discussion. The precise manner in which it is lost is shown, for instance, for *Adamsia* in the figures already referred to. It would, at any rate, aid in the explanation of the arrangement in Alcyonaria, *Edwardsia*, *Cerianthus*, *Zoanthus*, *Madracis*, &c. With regard to the Antipathidæ it would simplify the interpretation of the mesenteries in the various genera considerably. The three pairs of mesenteries first developed, viz., those termed "primary," are present in all genera. In *Cladopathes* the development of mesenteries ceases at this point. In *Antipathes*, *Antipathella*, *Aphanipathes*, &c., two other pairs are developed, but never become so important as the three primary pairs. In *Leiopathes* a further step is reached by the development of a sixth and still more rudimentary pair. Following

the hypothesis one step further, it will be seen that the Antipathidæ would thus need to be regarded as very primitive forms, which have not lost their bilateral symmetry, but which, in other respects, have gradually become specialised in one direction leading to dimorphism. *Edwardsia*, *Cerianthus*, *Zoanthus*, *Madracis*, &c., would also represent types in which the bilateral symmetry of parts is preserved, and the fact that *Edwardsia* is generally regarded as a very primitive form tends further to support this view.

The general plan of development may be stated as follows:—The mesenteries have a radiate arrangement in forms with a round stomodæum; this arrangement becomes bilateral by an elongation of the stomodæum in one axis, the sagittal. In this case the anterior and posterior pairs (directives) come to consist of adjoining mesenteries, whilst the intermediate pairs consist of opposite mesenteries. New mesenteries are added between any or all of the lateral pairs, the space between two existing mesenteries being divided in two on the formation of a new one. So long as the folds of the body-wall give rise to only one mesentery each, the simple bilateral arrrangement of parts is retained, as in Cerianthidæ. In case the mesenterial rudiments give rise (after the formation of the first twelve mesenteries) to two mesenteries instead of one, the Hexactinian type is reached. In certain Madreporaria (*e.g.*, *Lophohelia*, *Mussa*, and *Euphyllia*) the radiate arrangement appears never to be lost.

The different position of the retractor muscles in Alcyonaria and *Edwardsia* requires explanation; their intraseptal situation in the lateral pairs of Hexactiniæ is more easily understood. The fact that in Antipathidæ, Cerianthidæ, and Zoanthidæ the septal musculature is more or less rudimentary may indicate that the special differentiation in other types is of later origin.

A further discussion of the subject must be deferred until I have been enabled to study the whole of the material at my disposal.

Complete and Incomplete Mesenteries.

A comparison of the relations of the mesenteries in *Leiopathes* with the structure of a typical Actinian will show an important point of divergence. In *Leiopathes* and other Antipathidæ, in which the number of mesenteries in the oral cone is greater than in the lower section of the cœlenteron, the following points have an important bearing on their origin. The mesenteries, which have for convenience been termed "secondary," are those which do not reach the lower section of the cœlenteron, and which in certain genera appear not to be developed at all. The behaviour of these mesenteries is most interesting. In the upper portion of the oral cone they constitute short partitions, stretching from the stomodæum to the outer wall. A little lower down they lose their connection with the oral cone, and persist for some time as mesoglœal processes, clothed with entoderm, which project from the cœlenteric surface of the stomodæum. The mesoglœa of the projection

is continuous with that of the stomodæum. In most cases the "secondary" mesenteries never reach the lateral body-wall; the "primary" mesenteries always do so. It will be seen, however, that the relation of the mesenteries in such cases is precisely the reverse of that found in Actiniaria. In Actiniaria a mesentery is said to be "complete" when it extends from the body-wall to the stomodæum, and "incomplete" when it does not reach the stomodæum. In many Actiniaria new mesenteries are first recognisable in the angle between the pedal disc and the body-wall. They are usually regarded as involutions of the pedal disc and body-wall. In the genus *Halcampella*, for example, there are six well-developed pairs of mesenteries, and in addition a variable number of rudimentary "accessory" ones. "The accessory septa are small projections, which in the upper part of the body alone emerge from the angle between the body-wall and oral disc."[1] Thus the terms "complete" and "incomplete," as applied to the mesenteries of Zoantharia generally, are not applicable in the case of Antipathidæ. The behaviour of the "secondary" mesenteries in that family appears to indicate that they arise as outgrowths of the peristome and stomodæum, and not as involutions of the body-wall. All are complete in the sense that they are united with the mesoglœa of the stomodæum. Those which are incomplete become so from the fact that they lose their connection with the outer wall, not with the stomodæum.

Dimorphism.

The dimorphism of the Schizopathinæ is probably the most interesting point brought out by a study of the Challenger Antipatharia. In its result it is comparable to the nutritive and sexual zooids of certain Hydroids, but its mode of production is quite different. There appears no parallel case in the Cœlenterata so far as I am aware. The gastrozooids and dactylozooids of Hydracorallinæ have no resemblance, the latter type being modified solely for defensive and offensive purposes. Amongst the Alcyonaria dimorphism obtains in Pennatulidæ, certain Alcyonidæ, Pseudaxonia, &c. The autozooids are of normal structure. The siphonozooids are usually without tentacles, and have a well-developed siphonoglyphe; they are usually sexless, but in certain Pseudaxonia, *Corallium*, &c., bear ova, and apparently sometimes develop into autozooids. In the Zoantharia the only case of dimorphism known to me is that described by Fowler in *Madrepora durvillei*. In this species the dimorphism chiefly affects the structure of the mesenteries. In type A the abaxial directives and the mesenteries numbered 3, 5, 8, and 10 (fig. 15) have a median thickening which contains a narrow canal, lined by ectoderm, opening at both ends into the stomodæum. From the upper aperture the canal passes somewhat horizontally into the mesenterial thickening, becomes bent vertically downwards, and then turns round and takes an upward course, finally opening

[1] R. Hertwig, Challenger Actiniaria (Suppl.), Zool. Chall. Exp., pt. lxxiii. (vol. xxvi.) p. 32.

again into the stomodæum at a point only slightly below the upper aperture. From the arrangement of the ectoderm cells lining this canal, Fowler thinks that a current passes through it from the upper to the lower aperture, and that the modification is probably connected with nutrition and the presence of symbiotic Algæ. The remaining six mesenteries are of the usual structure, and have no ectodermal canals. They cease at the base of the stomodæum. The six modified mesenteries have a longer course, but those numbered 4 and 9 are longest, and bear reproductive organs. In type B none of the mesenteries are modified, but all have the same relative length as in type A. Numbers 4 and 9 are, in this type also, the only ones bearing reproductive organs. Both types appear to be reproductive, and both are digestive, but type A seems to be more digestive than type B, and may indicate a partly specialised gastrozooid. On the other hand type B is more reproductive than type A; ova were only observed in a single instance in the latter type. Fowler compares the elongation of mesenteries 4 and 9 to the transverse mesenteries of Antipathidæ and to the elongate ones in Alcyonaria. In *Madrepora aspera* none of the mesenteries are specialised. The dimorphism in *Madrepora durvillei* probably indicates a partial specialisation of certain zooids into gastrozooids and others into gonozooids, but the specialisation is not complete in either case. Its tendency is evidently in the same direction as the dimorphism of the Schizopathinæ, but in the latter group the specialisation is complete, and is brought about in an entirely different manner.

In the Schizopathinæ the dimorphism consists in the formation of gastrozooids and gonozooids. This differentiation is not apparently brought about by the specialisation of separate individuals as in other cases, but by a division of one primitive zooid into three portions, a central one containing the stomodæum, and two lateral portions bearing the reproductive organs. The mode in which this is accomplished appears to be connected with an elongation in the transverse axis of the typical zooid of the Antipathidæ, and the leading steps in the process can be made out from a study of the various genera already known. The reproductive organs are in all genera of Antipathidæ confined to the transverse pair of mesenteries, which also bear the fully-developed mesenterial filaments. The sagittal mesenteries sometimes have rudimentary mesenterial filaments, but these apparently never occur on the secondary ones. In zooids with a rounded outline an inequality in the breadth of the primary mesenteries, from body-wall to stomodæum, is connected, in such types as *Cirripathes*, with an elongation of the stomodæum in the sagittal axis. The transverse sections of the cœlenteron are therefore larger, and contain the reproductive organs as somewhat hemispherical bodies applied to each side of the mesentery. In *Antipathella* the zooids are small, and in those arranged on the more delicate portions of the axis, which form the great majority, there is a slight elongation of the body axis in the direction of the skeletal axis—that is in the line of growth. By this means the previously rounded zooid becomes transformed into an oblong one, and

the elongation in the transverse axis brings about an arrangement of the tentacles in two subparallel rows of three each. If one were not acquainted with the arrangement of the mesenteries, the tentacles might be described as consisting of an anterior, a middle, and a posterior pair. In *Antipathella* the tentacles are close together, and younger zooids still show them somewhat radiately arranged. In *Parantipathes*, however, the difference between the length of the zooid in the transverse and sagittal axes is very great, so that the tentacles, still arranged in rows, become considerably isolated. In this case there is a faint indication of a division of the zooid into three lobes, each bearing two tentacles. This is brought about by a slight depression in the peristome on each side of the stomodæum. This depression crosses the transverse axis at right angles, and pushes down the transverse mesenteries before it for a short distance. In *Parantipathes larix* the cœlenteron is thus imperfectly divided into three lobes, the central containing the stomodæum and all the mesenteries, the lateral lobes only the distal portions of the transverse mesenteries. The reproductive organs are confined to those sections of the transverse mesenteries situated in the lateral lobes of the cœlenteron. From this type the dimorphism in *Schizopathes* is easily derived by the formation of a mesoglœal partition in each depression of the peristome which, passing down to the base of the zooid, divides it into three individuals, a central gastrozooid and two lateral gonozooids. In the *Parantipathes* type the cœlentera of the various zooids on a pinnule are in communication by means of a basal prolongation of each. The hex-tentaculate individuals are imperfectly separated from one another by mesoglœal partitions which do not reach the base. In *Schizopathes* similar mesoglœal partitions separate the dimorphic individuals from each other, as well as one triplet from another. In *Schizopathes* there are, typically, no prolongations of the cœlentera in the direction of the branch, because all are closely packed, as in *Pteropathes* amongst the Antipathinæ. In *Bathypathes*, on the other hand, the dimorphic individuals are always separated from each other by a considerable interval, and an interzooidal communication is kept up by lateral prolongations of their cœlentera. Thus the Schizopathinæ appear to be directly derived from the Antipathinæ. The transition is brought about, first by an elongation of a zooid along the axis of a branch, and secondly by a division of such an elongate zooid into three individuals by the formation of two vertical mesoglœal partitions, one on each side of the stomodæum. *Parantipathes larix* forms an interesting link between the two subfamilies.

Colony Formation.

The production of a colony from the primary oozooid has not been observed, but it is possible to gain a general idea of the process from an examination of the blastozooids of an existing colony. New zooids are added by a form of budding in all essential features similar to that which obtains in Gorgonidæ. The process is probably

similar in other colonial Zoantharia, but in Madreporaria is apparently more complex, due, doubtless, to a lack of regularity in the position of the blastozooids and to the modifications necessitated by the presence of a calcareous exoskeleton. In *Leiopathes glaberrima*, for example, the zooids are frequently separated from each other by a considerable interval; they are irregular in size, and a close examination shows that very young ones are scattered here and there, which are only recognisable as slight rounded prominences, without a mouth or tentacles; others show a depression in the centre of the prominences, and those still further advanced show the rudiments of tentacles. In transverse vertical sections the zooids are seen to be connected together by tubular outgrowths of their cœlentera, running along the axis of the branch between the zooidal tissue proper and the cellular sheath of the sclerenchyma. The zooids are imperfectly separated from one another by vertical mesoglœal partitions which do not reach the sheath of the sclerenchyma, thus leaving a free communication between the cœlentera of adjoining zooids. In such sections passing through a very young zooid the elevation of the surface ectoderm, which indicates the position of the new zooid, is seen to correspond with a dilation in the cœlenteron. This dilation is situated in the narrow lateral out-

Fig. 18.—Diagram of the formation of new zooids by means of buds (*Leiopathes*).

growth, passing on to the next adult zooid, and at a point not far from the mesoglœal partition separating the tissues of the two adults. A diagrammatical representation of the arrangement is shown in fig. 18. In *Leiopathes* apparently a new zooid may be added at any point along the branch, its cœlenteron being at first a dilation of that of one of the adults. This type of budding gives rise to great irregularity in the size of the individual zooids on a branch. Sometimes large and small zooids appear to alternate with one another, but more usually the sequence is irregular. Pourtalès called attention to this feature in *Leiopathes glaberrima* (*cf.* Pl. IV. fig. 9). I have noticed it also in *Antipathella subpinnata* and other forms, but it appears most marked in *Leiopathes*. In *Antipathella subpinnata* the zooids in the basal two-thirds of a branch are usually very regular in size, the new zooids being apparently introduced chiefly between zooids of the newer portion of the colony. In the unbranched species *Stichopathes pourtalesi*, according to the observations of Pourtalès, large and small zooids alternate with considerable regularity. Ova were observed in the large ones, and Pourtalès suggests that the smaller ones may differ in sex. In all the species of Antipathidæ I have yet examined the zooids

of a colony always agree in sex, so that it appears more probable that the irregularity in size in this case is due to the prevalence of a type of budding similar to that which obtains in *Leiopathes*. In the Schizopathinæ, on the other hand, I have failed to recognise any interposition of smaller zooids between those of normal size. A difference in size is often to be seen, it is true, but this only affects the gonozooids and depends on the condition of the reproductive organs. In other respects the regularity in size is most marked (*cf.* Pl. VIII. fig. 1), and contrasts forcibly with the arrangement in *Leiopathes*. In this case new zooids appear to be added chiefly, if not entirely, at the apex of each branch, where there is a thickened mass of tissue as yet undifferentiated.

Cœnenchyma.

The cœnenchyma consists of the basal portions of the polyps with their connections with adjoining polyps. Its relative importance varies very much in different genera. In the genus *Cirripathes* it forms a sheath around the relatively thick sclerenchyma in which the polyps are imbedded. In this genus the interzooidal areas are divided by means of mesoglœal septa into a number of canals having a course mainly transverse to the sclerobasic axis. These communicate with the base of each zooid in the manner shown in Pl. X. fig. 13. Whether *Stichopathes* agrees with *Cirripathes* in having such a type of interzooidal communication is uncertain. Pourtalès recognised certain more transparent areas in the interzooidal tissue of *Stichopathes pourtalesi*, but did not make sections. The fact that *Stichopathes*, like the branched Antipathidæ, has the zooids arranged in a single longitudinal series, would lead one to suppose that it possesses a similar means of intercommunication between the zooids.

In *Leiopathes* and other genera with a branched sclerenchyma the zooids are usually distributed in a single row on one aspect of the skeleton only. In these cases the fused bases of the polyps form a hollow tube in which the sclerenchyma is formed. The three layers of the polyps are all represented in the cœnenchyma. Externally there is a layer of ectoderm continuous with that of the body-wall of each polyp, in the middle a layer of mesoglœa, and internally a layer of entoderm. At a point opposite the polyps a slender longitudinal mesoglœal septum occurs passing from the mesoglœa for a short distance towards the zooidal cœlentera. This becomes thickened at the free margin, and contains a large central lumen lined by the axis epithelium. In this cavity the sclerobasic axis is formed, which ultimately fills up the whole lumen. Thus the sclerenchyma is contained within a dilation of a free longitudinal septum inserted into the mesoglœa of the cœnenchyma at a point opposite the zooidal surface. The skeletal sheath also includes a layer of entoderm continuous with that of the polyps, which forms the median portion of the floor of their cœlentera.

In such forms as *Pteropathes fragilis* the cœnenchyma is confined to the back of each branch, the zooids on the anterior surface being so closely packed together that there is no room for interzooidal tissue. In other cases where the polyps are more isolated, the connections between the polyps on the anterior surface of each branch contain prolongations of their cœlentera. Mesoglœal septa usually occur, which incompletely separate the individuals from one another.

Skeleton Formation.

The axial skeleton in all Antipathidæ consists of thin concentric horny lamellæ arranged around an axial lumen, which is usually central in position. When a number of layers are superimposed the colour is usually dark brown or black; in thinner portions of the corallum the colour is golden brown. In a number of species the older portions of the corallum become covered with a glossy varnish-like substance, which is sometimes so thick as to cover all but the apices of the spines. The lumen of the axis appears to be divided by thin irregular partitions into a number of small chambers. The sclerenchyma is surrounded by a more or less complete layer of flattened cells, which G. v. Koch terms the *axis epithelium*. This is surrounded by a mesoglœal sheath, and the whole is clothed with entoderm. The mesoglœa of the sheath is connected with that of the cœnenchyma by means of a short longitudinal septum running the whole length of a branch. V. Koch suggests that the axis epithelium, which evidently secretes the sclerenchyma, has an epiblastic origin. In this case the axis epithelium is comparable with the *calycoblasts* of V. Heider, which secrete the calcareous skeleton in Madreporaria. I have not yet fully studied this point, but so far as my observations go they appear to support v. Koch's view. In *Schizopathes crassa* transverse sections of the apex of a branch show an involution of the ectoderm which is continuous with the mesoglœa adjoining the mesoglœal sheath of the sclerenchyma, but I have not yet traced the lumen from the invagination to the interior of the sheath. Further details must be deferred until I have made a more complete investigation of the material in hand.

Origin and Arrangement of Spines.

Pourtalès was the first to lay stress on the form and arrangement of the spines which are present on the axis of all Antipatharia, with the exception of *Savaglia lamarcki*. He thought them to present such manifold variations in shape and arrangement as to offer valuable characters for specific purposes. Although perhaps the spines do not afford absolutely reliable characters, it nevertheless appears probable that there is a "typical" arrangement in certain portions of the corallum which is constant in each species. It may be added further, that the typical arrangement

in the various species examined (over 60) is so varied as to supply valuable characters for the identification of species. It must, however, be stated generally that the spines vary very considerably in length and shape in almost every species examined. Whatever may be the form of spine possessed by any particular species, whether triangular, cylindrical, or knobbed, the specific features are never well marked at the apex of a branch. If one follows the contour of the spines from the apex of a branch downwards to its base, and on to the main stem if need be, a variety of outline is presented which may be conveniently divided into two sections, progressive and retrogressive. In the Schizopathinæ, in which the apical portion of a branch is usually membranous for a considerable distance, the first formation of spines is more easily traced. They arise first as longitudinal thickenings of the sclerenchyma, which are usually very narrow. The deposition of additional layers causes an increasing thickening of the central portion of each ridge, so that gradually a spine is evolved which varies in size, shape, &c., according to the species. The longitudinal ridges may remain, connecting a series of spines in irregular longitudinal series, or may become lost altogether. In any case the spines become elaborated up to a certain point, which may be considered "normal." The distance from the apex at which the first normal spines occur is very variable, and is certainly much greater in most Schizopathinæ than in the Antipathinæ. From this point onwards for a variable distance the normal character is maintained, although irregularities of arrangement may occur. In still older portions of the corallum the normal character is lost and the retrogressive period sets in. Perhaps the most typical form of retrogression is to be found in such forms as *Parantipathes larix*, in which the normal spines are elongate, somewhat cylindrical, and tapering. In this case each new layer of sclerenchyma adds a new film to each spine, which in consequence becomes gradually reduced in length, and assumes a more stunted form with a broader apex. A continuation of this process may reduce the spines on the stem to the form of granules, or they may be obliterated completely as in *Leiopathes glaberrima*. This, however, is not the only means by which the "normal" character is lost. In some cases it appears as if the secretive power of the axis epithelium of a spine more than keeps pace with that of the general surface of a branch, and that additions may be made to the apex of a spine without materially increasing its thickness below. For example, in *Antipathella subpinnata* the spines on the main branches are longer and relatively more slender than those above. In other cases the spines near the base of a colony become much elongated and dendritic; such is the case in *Antipathes spinosa* and *Antipathes myriophylla*. Forked spines are of frequent occurrence in many species as an abnormality (?), but in *Stichopathes gracilis* this feature is normal, and leads to the formation of double spines. At first all the spines are simple and subtriangular, a little lower down certain spines become bifid at the tip. The layers of sclerenchyma subsequently formed make this bifid character more pronounced, and also tend to cover up the

simple base. In this way a double spine (V-shaped) is formed, and later, by a continual increase in the thickness of the sclerenchyma, the originally simple spine becomes converted into two, which at first are recognisable on account of their close proximity, but which tend to become more and more isolated. It will thus be seen that drawings of the spines, in order to be of value in the identification of species, must be taken from certain more or less limited areas. On this account many of the drawings of Pourtalès are not satisfactory, because they represent the arrangement at the apex of a branch, where, as already stated, the specific features of the spines have not yet been assumed. In most Antipathidæ with moderately long pinnules it is necessary to pass over half an inch at any rate before the normal characters obtain regularity. In the illustrations of the arrangement of spines accompanying the present Report, I have, wherever possible, examined a branch or pinnule from the apex downwards, selected an area which seemed to have "normal" spines, and then finally figured that portion of it which seemed to show best the arrangement of the spines on the axis. All are drawn to scale, and the details have been filled in by the aid of an eye-piece micrometer. The amplification is always given, and this should be borne in mind for purposes of identification, as it gives a clue to the diameter of the axis,—an important point in such cases.

Retrogressive Development.

The life-history of a zooid may be divided into two cycles, the one a progressive metamorphosis and the other a gradual retrogression leading to atrophy. It appears, however, that the retrogressive changes do not affect all species in the same way. In the Schizopathinæ, where new zooids are usually added at the apex of a branch, the first signs of retrogression are frequently to be found at a point some distance above the base. This consists at first in a greater isolation of the individual zooids. It sometimes happens, as in *Schizopathes affinis* (Pl. IX. fig. 2), that only the terminal portion of a branch presents the normal arrangement of zooids. In the lower portion the zooids gradually become more and more isolated, and at the same time the body of the zooid becomes so much reduced, that before the base of a branch is reached, all that remains is a pair of tentacles projecting beyond the cœnenchyma; these appear to retain their original form for a very long time. In other cases (*e.g.*, *Schizopathes crassa*) the individual zooids appear to remain functional for a longer period, and the retrogression may only be observable on the stem and basal portion of the colony. In *Schizopathes* and *Bathypathes*, however, the body of the zooid always appears to be lost first, and the tentacles remain for a considerably longer period to indicate its position. In the Antipathinæ the retrogressive changes take a different course. In many species the formation of new zooids as buds from the stolon-like out-growth of the cœlenteron of an adult, keeps up the supply of functional zooids in a given area for a longer period than would other-

wise be the case. In *Cirripathes* and *Stichopathes* the zooids on the basal portion of the stem become so much reduced that they are only recognisable as discoidal swellings of the cœnenchyma, presenting a median aperture. In such cases the tentacles appear to be lost first, and subsequently the body of the zooid becomes more and more reduced, until finally it is no longer recognisable. In *Pteropathes fragilis* the tentacles appear to be lost in a definite order. In the normal zooid the sagittal tentacles are larger, and situated at a much lower level than the other four. In spite of their size the sagittal tentacles are the first to be lost, and some distance from the apex of a branch the zooids have usually only four tentacles. Still lower down these become lost also, and soon the zooid is no longer recognisable. In the Antipathinæ generally the tentacles appear to be lost before the body of the zooid.

An attempt to indicate the phylogenetic relationship of the Antipatharia must be deferred until my account of the histology of the group has been completed. In the meantime it may be stated that there appears little evidence that the Antipathidæ are such degenerate forms as v. Koch has supposed. His views on the subject were based on a study of *Parantipathes larix*, which in many respects is quite an exceptional form. At first sight the irregularity in the length of the mesenteries of this species might appear to support v. Koch's view, but if the view which I have taken of their origin and homologies be correct, the shorter mesenteries must be regarded as imperfectly developed rather than degenerate. It appears to me more probable that the Actiniaria have become elaborated from a simple hexamerous type, having probably the bilateral symmetry of *Leiopathes*, than that the Antipatharia have become degenerated from Hexactiniæ with a large number of mesenteries. Although *Leiopathes glaberrima* possesses twelve mesenteries, whilst all other Antipathinæ, so far as we know at present, have only ten, it does not necessarily follow that the majority have lost two mesenteries and become degenerate from a hexamerous type having six pairs or more. The available evidence appears to point in the opposite direction. Six well-developed mesenteries (three pairs) are present in all Antipathidæ, whilst none have more than three fully developed pairs. *Cladopathes* amongst the Schizopathinæ has only three pairs of mesenteries in all. Next come *Antipathes*, *Antipathella*, and a number of other genera with five pairs, two of which are short and apparently not fully developed. The two additional pairs are situated one on each side of the transverse mesenteries which bear the reproductive organs. That it is to say, in *Antipathes*, &c., there are four lateral compartments on each side of the stomodæum, whereas in *Cladopathes* there are only two. Finally, in *Leiopathes* two opposite compartments bordering the transverse mesenteries become

further subdivided by the interposition of another pair of mesenteries, giving six in all. It therefore appears as if, within the family, three pairs represent the more primitive arrangement, and that those genera possessing five pairs, as well as *Leiopathes* with six, have been elaborated from it. This view appears also to be supported by our knowledge of the ontogeny of the Hexactiniæ. Neither *Sagartia dohrnii* nor *Savaglia lamarcki* appear to offer any assistance in a solution of the question. The former has been shown by Andres to be a true Actinian. The fact that *Sagartia dohrnii* secretes a horny basal membrane, which may become tubular, appears to have no phylogenetic value. Many true Actiniaria have the same power. *Savaglia* has nothing in common with Antipathidæ beyond the possession of a branched lamellate sclerenchyma, which, however, is always primarily parasitic, as in Amphianthidæ, but which may extend beyond the limits of the foreign basis. The zooid, so far as its structure is known, belongs to the true Actinian type, and has no similarity whatever to the zooid of Antipathidæ. The only essential point on which it differs from colonial Actiniaria appears to consist in the fact that the cœnenchyma possesses a series of interzooidal canals, one of which opens into the base of each interseptal chamber. It appears probable that some such communications must also exist between the zooids of certain Zoanthidæ (*e.g.*, *Epizoanthus stellaris*, R. Hertwig).

The spinose horny axis, which, excluding *Savaglia*, is peculiar to the Antipatharia, is related through *Dendrobrachia* to that of certain Gorgonacea. In certain portions of the axis of *Dendrobrachia* the sclerenchyma is rugose, with a spinose margin. In *Acanthoisis*, Wright and Studer, the axis consists of short calcareous nodes and more elongate horny internodes. The internodes are rugose with a dentate margin, giving an appearance very similar to the axis of *Dendrobrachia*. In *Gorgonella*, Val., the axis is horny and rugose, but without the dentate margin. Thus whilst the spinose sclerenchyma of Antipathidæ appears to be linked to that of Actiniaria through *Savaglia*, it on the other hand is linked to that of certain Gorgonacea through *Dendrobrachia*. The sclerenchyma of *Leiopathes glaberrima* too, the stem and main branches of which are always smooth and glossy, appears intermediate between that of normal Antipathidæ on the one hand and *Savaglia* on the other. On this account it appears probable that a truer knowledge of the systematic position of the Antipathidæ is more likely to be obtained by a study of the zooids than by a study of the sclerenchyma.

Finally, a few points in which the Antipatharia resemble certain other Zoantharia may be indicated; some of them have been already mentioned.

A general resemblance between *Savaglia* and Zoanthidæ is most marked, but it is as yet uncertain whether their mesenteries are arranged on the same plan. The arrangement in Zoanthidæ is most peculiar, and a renewed study of the arrangement in *Savaglia* is very desirable.

The Amphianthidæ, as R. Hertwig has already pointed out, bear a general resemblance

in form to certain Antipathidæ. In both families an elongation in the transverse axis is often marked. In Amphianthidæ, however, the stomodæum is usually elongated in the transverse axis, so that the siphonoglyphes, supported by the directive mesenteries, almost touch one another. In Antipathidæ the elongation in the stomodæum, when such occurs, usually takes place in the sagittal axis. It appears probable that the elongation in the transverse axis, characteristic of the Amphianthidæ, and also found though not always well marked in Antipathidæ, does not afford a character of phylogenetic value.

In *Dendrobrachia fallax* we have a form with branched tentacles, thus showing that the type of the tentacle once thought to be characteristic of Alcyonaria may occur also in Antipatharia as well as in Actiniaria.

CLASSIFICATION.

It will be well to consider briefly the value of the present collection for a rearrangement of the Antipatharia. In the past, owing to the lack of information concerning the organisation of the zooids, it has only been possible to make use of skeletal characters, the mode of branching, and the size, shape, and arrangement of the spines in the definition of both species and genera. Even Pourtalès, who has figured the zooids of several of the West Indian forms, and recognised two or three distinct types, considered it premature to attempt any rearrangement of the group based on the information at hand. I consider, however, that the information brought forward in the present Report, although, undoubtedly, not sufficient for a complete reorganisation of the group, throws sufficient light on the subject to indicate at any rate the lines on which future classification must be based, and a partial revision has been attempted in consequence. This seems the more justifiable on account of the relatively large number of species of which I have been enabled to make a microscopical examination of the zooids. Including the species now described as new, and supposing the synonymy here adopted to be correct, the list of species referable at present to the Antipatharia may be fixed at 98, and of many of these we have at present only the most meagre information, so that in many cases it is impossible to decide whether the list might not be still further reduced. Previous authors have only given us information concerning the structure of the zooids in three species, viz., *Savaglia lamarcki*, *Antipathella subpinnata*, and *Parantipathes larix*. G. v. Koch has more recently given us a more detailed account of the structure of *Parantipathes larix*, including a more accurate description of the number and position of the mesenteries. The other two species have not been examined by subsequent investigators, and Lacaze Duthiers' account of *Antipathella subpinnata* is very incomplete. Of the 97 species referred to I have been enabled to study the structure of the zooids of 22, viz., 16 Challenger species, 4 from the Mediterranean (including *Parantipathes larix* and *Antipathella subpinnata*), and 2 in the British Museum collection. An examination of these species, the detailed results of which I hope to publish in due course, has led me to the conclusion that a proper arrangement of the Antipatharia can only be completed when we possess accurate information concerning the morphology of all the species. A marked contrast between the Alcyonaria and the Zoantharia is found in the fact that,

whereas the number of tentacles and mesenteries is constant in the former order, it is most variable in the latter. In this respect the Antipatharia agree with other Zoantharia, at least to this extent that there is a variation in the number of mesenteries present in the various species already examined. This distinction has necessarily led to a difference in the characters selected as being of generic value in the two great sections of the Anthozoa. I am thus inclined to think that the method adopted by R. Hertwig in the classification of the Actiniaria will be likely to yield the most reliable results if applied to the Antipatharia also. The characters available for a classification of the Antipatharia are more limited than might be at first supposed. The sclerenchyma is apparently always chitinous, and is more or less spinose in all the species described, excepting *Savaglia lamarcki*, which constitutes the only known species of the Savagliidæ. The mode of branching has been generally admitted to give no characters of generic value, indeed, so far as can be made out at present, this feature is sometimes not even of specific value. For instance, in *Antipathes picea* and *Antipathes tanacetum*, described by Pourtalès, the two forms are said to be precisely similar in the mode of branching, the species being considered distinct on account of differences in the spines. The value of the mode of branching for generic purposes has already been partly discussed when considering the value of the genera proposed by Milne-Edwards. More need not be added at present. Further investigation may, however, show that some of the genera here defined (*e.g.*, *Aphanipathes*) may bear subdivision, and that in this case distinct types of branching may yield characters of value. With regard to the form, size, and mode of distribution of the spines, it may be stated that three distinct types, viz., cylindrical, triangular, and knobbed, have been observed; their value as an aid to classification does not at present seem clear. Undoubtedly, as Pourtalès has already pointed out, the form of the polyp frequently bears a definite relation to the form of the spines, but this is not invariably the case, and the three types are closely linked together by intermediate forms. The cylindrical type may become compressed and shortened, whilst in the other direction *Antipathes filix*, Pourtalès, forms a link between those forms having simple cylindrical spines and others, such as *Aphanipathes pedata* and *Aphanipathes cancellata*, in which the knobbed feature is most marked. We have thus to fall back on the structure of the zooids and cœnenchyma to supply the chief characters, and these are precisely the features which have hitherto received the least attention.

The characters to be considered of ordinal value depend to a great extent on whether the Savagliidæ are to be included in the Antipatharia. Undoubtedly *Savaglia lamarcki* has little in common with the Antipathidæ beyond the possession of a continuous and branched horny sclerenchyma and a non-spiculate cœnenchyma. Its zooid has the typical Actinian structure, and the system of canals in the cœnenchyma are, so far as is known at present, without parallel in the Antipathidæ. A horny sclerenchyma, such as that of *Savaglia*, is by no means confined to the Antipatharia. The colonial

Zoanthidæ amongst the Actiniaria have a similar axis, which in some cases, too, becomes tubular. In *Savaglia* the colonies are larger and more important, and apparently the sclerenchymatous sheath may be continued beyond the foreign substance which at first forms its support, but in both cases the growth is at first parasitic. In the Zoanthidæ it apparently never ceases to be so. On the other hand the zooid of *Savaglia* does not appear related to that of the Zoanthidæ. R. Hertwig and Erdmann regard the alternation of macro- and microsepta as the most prominent feature of the latter group, and this condition does not obtain in *Savaglia*. I have not been able to make sections of this species, and am unable to add anything to the researches of Lacaze Duthiers. Temporarily I have retained it amongst the Antipatharia, but it must be regarded as a genus quite apart, and one which may ultimately be included in the Actiniaria.

With the exception of *Savaglia* the most constant feature of the Antipatharia is the presence of spines on the axial horny sclerenchyma. This is a feature which, so far as I know, is only shared, and then in a modified manner, by one other genus of Anthozoa, viz., *Acanthoisis*, Wright and Studer. In this genus, the only one amongst the Gorgonidæ which appears to approach the Antipatharia in this respect, the axis consists of alternating calcareous nodes and horny internodes; the internodes have the surface raised in ridges, which are dentate.[1] Next in importance, and with the additional exception of the Dendrobrachiidæ (also at present limited to one species), we may consider the simple nature of the tentacles and the absence of a sphincter muscle, as a necessary result of which the tentacles cannot be covered by the upper portion of the body-wall. The former feature was until recently supposed to separate sharply the Zoantharia from the Alcyonaria. We now know, however, that certain families of Actiniaria (Sarcophianthidæ and Thalassianthidæ) have the tentacles branching or bushy, and thus approach the Alcyonarian type. *Dendrobrachia*, too, amongst the Antipatharia has pinnate tentacles. The presence of a sphincter muscle, though frequent in the Actiniaria, is not a constant feature. The group includes all grades of differentiation in this respect. Further, and again with the exception of *Savaglia*, the arrangement of mesenteries in the Antipatharia is constant, and in all genera yet described (? *Dendrobrachia*) they may be reduced to one type.

The characters which I have considered of generic value refer chiefly to the form of zooid and the number and relations of the mesenteries. The latter have been found to vary from twelve to six in the Antipathidæ. The following is the arrangement at present proposed :—

[1] Wright and Studer, Challenger Alcyonaria, Zool. Chall. Exp., pt. lxiv. (vol. xxxi.) p. 45, pl. viii. figs. 1, 1*a*, 1*b*.

ANTIPATHARIA, Milne-Edwards.

Antipathacea, Dana.
Ceratophyta (*pars*), Gray.

Colonial Zoantharia, possessing a continuous horny sclerobasic axis, which consists of thin concentric lamellæ usually enclosing a central canal. The horny axis is usually more or less branched, and is spinose in all known genera excepting *Savaglia*. The cœnenchyma consists of the fused bases of the zooids; it is always thin, and never contains any spicules proper to it. The sclerobasis may be independent or parasitic; in the latter case the sclerenchyma forms a sheath around some foreign body. The colony is generally fixed by a basal dilation of the sclerenchyma, but in some cases this is replaced by an elongate flattened hook-like base ending in a point. The sclerenchyma is probably a secretion of the ectoderm.

Family I. SAVAGLIIDÆ, n. n.

Gerardidæ, Verrill.
Antipathes (*pars*), Auctt.

Antipatharia the zooids of which possess 24 simple tentacles and 24 mesenteries, and are connected together by a cœnenchyma possessing a series of interzooidal canals opening into the base of each antimere. Sclerenchyma parasitic, not spinose. The tentacles may be completely covered in contraction by the anterior portion of the body-wall. The zooids have the typical Actinian structure.

Savaglia, Nardo, 1843. (= *Gerardia*, Lacaze Duthiers, 1864.)

Family II. ANTIPATHIDÆ, Verrill (*emend.*).

Antipatharia in which typically the individual zooids have six simple tentacles, but in dimorphic genera three individuals, each possessing only two tentacles, are morphologically equivalent to one zooid of the ordinary type. The tentacles are contractile, but apparently never "retractile." Sclerenchyma rarely parasitic, always spinose, and usually possessing a central canal. The cœnenchyma is not generally traversed by a number of interzooidal canals, but the individual zooids are brought into communication by a stolon-like lateral outgrowth of their cœlentera. Six primary mesenteries are always present, two of which occupy the transverse axis and bear the reproductive organs. There may be six or four secondary mesenteries which are always short, or these may be absent altogether. This family corresponds to the genus *Antipathes* as instituted by Pallas.

Subfamily Antipathinæ, Brook.

Zooids not dimorphic, each possessing six tentacles, which may be radiately arranged, or in two rows of three each. There is a tendency for the transverse axis of the zooid to become much elongated in the direction of the horny basis.

This subfamily corresponds to the family Antipathidæ of Verrill, and includes all the species of Antipathidæ previously described, of which the zooids are known. It includes the following genera :—

Cirripathes (Blainv.), *emend.*	*Antipathella*, n. gen.
Stichopathes, n. gen.	*Aphanipathes*, n. gen.
Leiopathes (Gray), M.-Edw. (*emend.*).	*Tylopathes*, n. gen.
Antipathes (Pall.), *emend.*	*Pteropathes*, n. gen.

Parantipathes, n. gen.

Subfamily Schizopathinæ, Brook.

Zooids dimorphic, each with two tentacles. Of the three individuals morphologically comparable with the unspecialised zooid of Antipathinæ, two are reproductive (gonozooids) and one is nutritive in function (gastrozooid).

The following genera belong to this group:—

Schizopathes, n. gen.	*Taxipathes*, n. gen.
Bathypathes, n. gen.	*Cladopathes*, n. gen.

Family III. Dendrobrachiidæ, Brook.

Antipatharia the zooids of which have branched "retractile" tentacles. The sclerenchyma is apparently without a central canal and is distinctly spinose. In the younger portions of a colony the sclerenchyma forms irregular plate-like longitudinal ridges varying in number, the angles between which are filled up by a further secretion of sclerenchyma, so that ultimately the axis becomes cylindrical as in the Antipathidæ.

Dendrobrachia, n. gen.

In seeking to establish new genera I have, with one exception, made a microscopic examination of the polyps of the type species. There are, however, so many species of which the polyps are not known that it is impossible at present to refer all to their proper position. Structural characters have not previously been taken into consideration, and authors have

relied chiefly on the mode of branching for specific purposes. In order to avoid a needless multiplication of genera, I have adopted one uniform course in the systematic section of this Report, in endeavouring to refer the various species to their respective genera. This may be shortly stated as follows :—

1. The species of which I have been enabled to examine the polyps have been referred without query to their respective genera.

2. A considerable number of species have been provisionally referred to one or other of the genera now proposed. These include many species of which figures or descriptions of the external appearance of the polyps have been given by Pourtalès and others; also a number of species the polyps of which are not known, but in which the mode of branching and type of spine appear to indicate an affinity to some better known form. In such cases a query has been added after the generic name when necessary.

3. Finally, a large number of species still remain which, in the absence of information concerning the polyps, have not appeared to possess sufficient characters in common with better known forms to justify their inclusion in any of the genera proposed. These have all been included as *species incertæ sedis*, but the section has been divided into two parts. The first includes those which appear to be good species, and the second those which are too imperfectly described for identification and the types of which I have not seen.

TABLE OF THE GENERA AND SPECIES OF ANTIPATHARIA INCLUDED IN THIS REPORT.

The species represented in the Challenger Collection are distinguished by an asterisk.

I. Savagliidæ, n. n.

Savaglia, Nardo.
Savaglia lamarcki (Haime).

II. Antipathidæ, Verrill.

α. Antipathinæ, Brook.

Cirripathes (Blainv.), *emend.*
Cirripathes propinqua, n. sp.
„ *anguina*, Dana.
„ *spiralis* (Linn.), Blainv.
„ ? *paucispina*, n. sp.
„ ? *flagellum*, n. sp.
„ ? *diversa*, n. sp.

Stichopathes, n. gen.
Stichopathes pourtalesi, n. sp.
„ *gracilis* (Gray).
„ *echinulata*, n. sp.
„ ? *desbonni* (D. and M.).
„ ? *occidentalis* (Gray).
„ ? *filiformis* (Gray).
„ ? *lütkeni*, n. sp.

Leiopathes (Gray), M.-Edw., *emend.*
Leiopathes glaberrima (Esp.), M.-Edw.
„ ? *lenta* (Pourt.).

Antipathes (Pall.), *emend.*
Antipathes dichotoma, Pall.
„ *arborea*, Dana.
„ *mediterranea*, n. sp.
„ ? *fœniculacea*, Pall. (*non* Esp.).
„ ? *virgata*, Esp.
„ ? *lentipinna*, n. sp.
„ ? *furcata*, Gray.

Antipathella, n. gen.
Antipathella subpinnata (E. and S.).
„ ? *boscii* (Lamx.).
„ ? *intermedia*, n. sp.
„ ? *strigosa*, n. sp.
„ ? *tristis* (Duch.).
„ ? *gracilis* (Gray).
„ ? *atlantica* (Gray).
„ ? *paniculata* (D. and M.).
**Antipathella assimilis*, n. sp.
„ *reticulata* (Esp.).
* „ *minor*, n. sp.
* „ *speciosa*, n. sp.
* „ *contorta*, n. sp.

Aphanipathes, n. gen.
**Aphanipathes sarothamnoides*, n. sp.
„ ? *salix* (Pourt.).
„ „ var. *rigida*, Pourt.
„ ? *fruticosa* (Gray).
„ ? *verticillata*, n. sp.
„ ? *alata*, n. sp.
„ ? *wollastoni* (Gray, MS.).
„ ? *barbadensis*, n. sp.
„ ? *pedata* (Gray).
„ ? *pennacea* (Pall.).
„ ? *eupteridea* (Lamx.).
„ ? *humilis* (Pourt.).
„ ? *thyroides* (Pourt.).
„ ? *filix* (Pourt.).
„ ? *abietina* (Pourt.).
* „ *cancellata*, n. sp.

Tylopathes, n. gen.
**Tylopathes crispa*, n. sp.
„ ? *flabellum* (Pall.), *non* Esp.
„ ? *dubia*, n. sp.
„ ? *hypnoides*, n. sp.
„ ? *elegans*, n. sp.

Pteropathes, n. gen.
**Pteropathes fragilis*, n. sp.

Parantipathes, n. gen.
Parantipathes larix (Esp.).
„ ? *tetrasticha* (Pourt.).
„ ? *fernandezi* (Pourt.).
„ ? *hirta* (Gray).
„ ? *columnaris* (Duch.).

β. Schizopathinæ, Brook.

Schizopathes, n. gen.
**Schizopathes crassa*, n. sp.
* „ *affinis*, n. sp.
* „ *conferta*, n. sp.

Bathypathes, n. gen.
**Bathypathes patula*, n. sp.
,, ,, var. *plenispina*, nov.
* ,, *alternata*, n. sp.
* ,, *lyra*, n. sp.
* ,, *tenuis*, n. sp.
Taxipathes, n. gen.
**Taxipathes recta*, n. sp.
Cladopathes, n. gen.
**Cladopathes plumosa*, n. sp.

III. Dendrobrachiidæ, Brook.

Dendrobrachia, n. gen.
**Dendrobrachia fallax*, n. sp.

Species incertæ sedis.

Arachnopathes, M.-Edw.
Arachnopathes ericoides (Pall.), M.-Edw.
,, *clathrata* (Pall.), M.-Edw.
,, *aculeata*, n. sp.
[*Antipathes*].—The species referred to the genus *Antipathes* in its unrestricted sense (= Antipathidæ), which it is not at present possible to refer to any of the new genera proposed, nor to the genus *Antipathes* as now restricted, are referred to under the original generic name placed within square brackets.

[*Antipathes*] *corticata*, Lamk.
,, *picea*, Pourt.
,, *tanacetum*, Pourt.
,, *arctica*, Lütken.
,, *abies* (Linn.), Gray.
,, ,, var. *paniculata*, Esper.
,, *pumila*, n. sp.
* ,, *cylindrica*, n. sp.
,, *spinescens*, Gray.
,, ,, var. *minor*, nov.
,, *squamosa*, Koch.
,, *myriophylla*, Pall.
,, *panamensis*, Verrill.
,, *ulex*, E. and S.
,, *spinosa* (Carter).
,, *japonica*, n. sp.
,, *bifaria*, n. sp.

Species dubiæ.

[*Antipathes*] *alopecuroides*, E. and S.
,, *triquetra*, Brug.
,, *lacerata*, Lamk.
,, *pectinata*, Lamk.
,, *taxiformis*, Duch.
,, *melancholica*, Duch.
,, *americana*, Duch. and Mich.
,, *isidis-plocamos*, Klunz.

DESCRIPTION OF SPECIES.

Family SAVAGLIIDÆ, n. n. (GERARDIDÆ, Verrill).

Genus *Savaglia*, Nardo.

Gorgonia (*pars*), Donati, Lamarck, &c.
Savaglia, Nardo, 1843, Atti 5 Congresso d. sc. ital. in Lucca.
Leiopathes (*pars*), Gray, Haime, Milne-Edwards, &c.
Antipathes (*pars*), Lamarck.
Gerardia, Lacaze Duthiers, 1864, Ann. Sci. Nat. (Zool.), sér. 5, t. ii. p. 169.

Parasitic Zoantharia, living mostly on the stems of Muriceidæ and other Gorgonidæ, around which they secrete a black chitinous covering. On this account the mode of branching is not characteristic of the *Savaglia*, but of the species on which it is parasitic. In old specimens, where the chitinous stems extend beyond the Gorgonid base, the growth becomes bushy. Sclerenchyma black, and covered with crateriform papillæ. Polyps cylindrical, having twenty-four tentacles and mesenteries; the tentacles are capable of retraction, in which case the whole polyp assumes a nipple or wart-like appearance. The cœnenchyma contains a series of canals bringing the whole of the blastozooids of a colony into communication through the bases of the interseptal chambers.

Lacaze Duthiers was the first to show the true relations of this form, and its difference from the typical Antipathidæ. Nardo, in 1843, gave the generic name *Savaglia* to the species described as *La Savaglia* by Donati in 1765, which he says is identical with *Leiopathes lamarcki*, Haime; in this case his name has priority over that of *Gerardia*, instituted by Lacaze Duthiers in 1864. This I gather from a more recent paper; I have not seen the original, and do not know if Nardo gave the species a specific, as well as a generic, name; there is no mention of one in his recent publication. I have, therefore, retained the specific name of Haime. Although it seems highly probable that Nardo's *Savaglia* is the same as *Gerardia*, Lacaze Duthiers, his description of the polyp does not agree with Lacaze Duthiers' observations on living specimens. Nardo states that the polyp has only fourteen tentacles, whereas the species in question has twenty-four.

Savaglia lamarcki (Haime).

Gorgonia tuberculata (*pars*), Lamarck, Hist. nat. anim. sans vert., t. ii. p. 315.
Gorgonia savaglia, Bertolini, Amenitatio Italica, p. 219.
Savaglia sp., Nardo, Atti 5 Congresso d. sc. ital. in Lucca, 1843; also Atti Istit. Veneto, ser. 5, t. iii. p. 673.
Antipathes glaberrima (*pars*), Lamarck, *op. cit.*
? *Leiopathes glaberrima* (*pars*), Gray, Proc. Zool. Soc. Lond., 1857.
Leiopathes Lamarcki, Haime, Ann. Sci. Nat., sér. 3, t. xii. p. 284; Milne-Edwards, Coralliaires, t. i. p. 322.
Gerardia Lamarcki, Lacaze Duthiers, Ann. Sci. Nat., sér. 5, t. ii. p. 169, &c.

A full description of this, the only known species of Savagliidæ, has been given from the researches of Lacaze Duthiers at p. 51, and, as the definitions of both family and genus rest on a single species, these need not be repeated.

Habitat.—Mediterranean. Near African shores (Lacaze Duthiers), Adriatic (Nardo, Heller).

Family Antipathidæ, Verrill, *emend.*

Antipatharia in which the individual zooids have typically six simple tentacles. In dimorphic genera three individuals, each with two tentacles, represent morphologically a single six-tentacled zooid of the ordinary type. Sphincter muscle not developed; the tentacles are therefore only contractile and cannot be enclosed by the margin of the peristome. There are always three pairs of well-developed primary mesenteries, one pair of which occupies the transverse axis and bears the reproductive organs. There are usually two or three other secondary pairs of mesenteries present which rarely extend below the oral cone, and never bear mesenterial filaments. Sclerenchyma chitinous, rarely forming a parasitic growth, and always bearing spines on the newer branches. Usually these are present on all parts of the corallum. Cœnenchyma not traversed by numerous canals, as in the Savagliidæ, but, instead, the individual zooids are usually brought into communication by stolon-like outgrowths of their cœlentera.

The sclerenchyma consists of thin, concentric, horny layers around a central lumen, and always bears a number of spines on its surface which are usually recognisable on all parts of the skeleton, but, in some cases, they may be confined to the more slender portion of the corallum.

This family corresponds closely with the genus *Antipathes* as defined by Pallas.

Subfamily Antipathinæ, Brook.

Antipathidæ the zooids of which are of the simple type with six tentacles, all springing from the peristome, or two, in the sagittal axis, may be inserted at a lower level. Zooids

either radiate, oval and biradiate, or much elongated in the transverse axis. Mouth rounded, or more usually elongated in the sagittal axis. Corallum simple or branched.

Table of Genera.

A. Indivisæ. Corallum a simple flagellate stem, entirely without branches.
- 1. Polyps disposed all around the stem, ... *Cirripathes* (Blainv.), *emend.*
- 2. Polyps forming a single longitudinal row, on one aspect of the stem, *Stichopathes*, n. gen.

B. Ramosæ. Corallum branched, with or without confluence of branches.

α. Polyps with twelve mesenteries in the oral cone, six below.
- 3. Corallum dendriform, stem and thicker branches polished, without spines; branchlets spinose; spines very small and distant, . *Leiopathes* (Gray), *emend.*

β. Polyps with ten mesenteries in the oral cone, six below.
- 4. Polyps large, rounded; tentacles radiating, those in the sagittal axis inserted much lower than the others; corallum shrub-like; branches free; spines strong and usually numerous, ... *Antipathes*, Pall. (*emend.*).
- 5. Polyps small, oval; tentacles disposed in two rows of three each; corallum extending more or less in one plane, with or without confluence of branches; spines usually short and somewhat triangular, ... *Antipathella*, n. gen.
- 6. Polyps obscure, oval, frequently hidden by the elongate spines; tentacles very short; corallum pinnate, paniculate or flabellate, with or without confluence of parts; spines elongate and slender, . *Apkanipathes*, n. gen.
- 7. Polyps forming oval cushion-like prominences on the cœnenchyma; corallum much branched and flabellate, with more or less fusion of parts; spines short, as in *Antipathella*, ... *Tylopathes*, n. gen.
- 8. Polyps small, crowded so as to have a somewhat rectangular outline; sagittal tentacles inserted into the base of the polyp; corallum flabellate; spines very long and stout, ... *Pteropathes*, n. gen.
- 9. Polyps much elongated in the direction of the horny axis; tentacles elongate, arranged in couples, separated by a considerable interval; spines short and distant, ... *Parantipathes*, n. gen.

Section I. INDIVISÆ.

Genus *Cirripathes* (Blainv.), *emend.*

Gorgonia (*pars*), Linn., Systema naturæ.
Antipathes (*pars*), Auctt.
Cirrhipathes, Blainville, Manuel d'Actinol., p. 511; Dana, Zooph., p. 574; M.-Edwards, Coralliaires, t. i. p. 313.
Cirrhipathes (*pars*), Gray, Proc. Zool. Soc. Lond., 1857, p. 290; Duchassaing and Michelotti, Mem. Acad. Torino, t. xix. and xxiii.; Duchassaing, Rev. d. Zooph. &c., d. Antilles; Pourtalès, Bull. Mus. Comp. Zoöl., 1880, &c.

Antipathinæ having an elongate unbranched corallum, around which the polyps are distributed subspirally in several irregular rows, never in a single linear series. The zooids are usually rounded in outline, and are provided with six tentacles arranged in a

radiate manner. The mouth is situated on a more or less prominent conical projection of the peristome, which may show a constriction at its base. There are five pairs of mesenteries in the oral cone and three below.

The cœnenchyma consists of the tissue uniting neighbouring zooids; it contains a system of canals which takes a direction chiefly at right angles to the axis of the stem, and communicates with the bases of the individual zooids.

Synopsis of Species.

A. Spines all of one type.

1. Stem stout, straight, or slightly flexuose; spines short, conical, and close-set, not hooked, very small on one side of the axis, and gradually increasing in length towards the other, distributed in irregular longitudinal rows, . . . *propinqua*, n. sp.
2. Stem stout, straight, flexuose or contorted; spines conical, subequal, close-set, somewhat bent upwards, irregularly arranged, sometimes in transverse rows, . *anguina*, Dana.
3. Stem not usually so stout, twisted into subregular spirals; spines conical, arranged spirally, shorter on the inner than on the outer margin of the spiral axis, ... *spiralis* (Linn.).
4. Stem light brown instead of black, with six longitudinal rows of distant short spines, ... *paucispina*, n. sp.

B. Spines of two distinct types.

5. Stem very long, not spiral; large spines conical, elongate, pointed, and usually covered with small granulations; small spines very slender and relatively elongate, distributed irregularly between the larger ones, . . . *flagellum*, n. sp.
6. Stem spiral, as in *Cirripathes spiralis;* large spines stout, cylindrical, with a blunt apex, arranged spirally; the interval between the large spines is filled in with a number of very short triangular spines with a sharp apex, . . *diversa*, n. sp.

Cirripathes propinqua, n. sp. (Pl. X. figs. 9–13; Pl. XII. fig. 14; Pl. XIV. fig. 7).

Axis straight or slightly flexuose, not spiral, clothed with short, conical, closely set spines, which are larger on one side of the stem than on the other.

The type of this species is in the British Museum collection, and was received through the Sydney Museum from Cape Moresby, New Guinea. The specimen consists of two portions of the axis, each about 30 cm. long, densely clothed with cœnenchyma, in which the polyps are imbedded. The soft parts are well preserved. The stem is about 3·75 to 4·25 mm. in diameter, somewhat irregular, but only slightly tapering in the parts preserved.

The spines are short, thick, and conical, with a blunt apex, and stand out at right angles to the stem; the apex is not curved upwards, as in *Cirripathes anguina*, and, unlike that species, the spines are here of different lengths (Pl. XII. fig. 14). On one side they are very short, and gradually become longer towards the opposite side. The longest are similar to the long spines of *Cirripathes spiralis*. From fourteen to sixteen rows may be counted from one aspect, but in the thicker portions of the stem the spines are

more numerous. In the form of the axis and character of the spines, this species comes nearest to *Cirripathes anguina*, Dana, from which, however, it differs, in having shorter and more numerous unequal spines, arranged in irregular longitudinal rows. The sclerenchyma is about 1·4 mm. thick, black and shining, the diameter of the central canal being slightly less than one-third of that of the axis. I have not noticed the nodes in the axis, mentioned by Dana as occurring at irregular intervals in *Cirripathes anguina*, but as this specimen had the polyps well preserved all over the axis, it did not seem advisable to disturb them any more than actually necessary. The polyps (in spirit) are dull black, rounded in outline, and stand out prominently from the cœnenchyma, which is relatively thin and pale. The polyps are a little irregular in size, and average about 1·5 mm. in diameter. About five are distributed to each centimetre in the length of the axis, but not quite in a straight line. The height of the polyps from the cœnenchyma to the tip of the tentacles is usually about 1·7 mm. The polyps are distributed somewhat spirally, but the arrangement is irregular. The mouth is situated on a prominent oral cone, which is constricted at the base, where it joins the general surface of the peristome. In specimens preserved with the mouth open, the outline presents ten crenations due to an evolution of the stomodæum, but at first sight appearing like ten stunted circumoral tentacles. The crenations correspond with the ten inter-septal chambers which are continued into them. The tentacles are short, thick, and rapidly tapering, and are frequently laid around the mouth in spirit specimens (Pl. X. figs. 9 and 12).

This being the only species of the genus of which I have been enabled to examine sections, it may be well to add a few words concerning the structure of the cœnenchyma. In most Antipathidæ the polyps are normally distributed along the branches in a single linear series, in which case neighbouring polyps are brought into communication with one another by two stolon-like outgrowths of their cœlentera occupying the transverse axis of the polyps. In this genus the polyps are distributed all around the stem, and the cœnenchyma is, consequently, not so important, consisting only of interzooidal areas which correspond with that portion of the cœnenchyma in other forms occupying the zooidal surface of the stem or branch. The interzooidal communication is also apparently brought about in a different manner. The cœnenchyma contains a number of irregular canals, collected into groups in the interzooidal areas, which take a general direction at right angles to the axis of the stem. These communicate with the base of each polyp at one or more points (Pl. X. fig. 13). Thus the interzooidal canals in the genus appear to be more nearly related to those of *Savaglia* than to those of the majority of other Antipathidæ. Whether *Stichopathes* agrees with *Cirripathes* in this respect is at present uncertain, but the observations of Pourtalès seem to support such a view. In *Stichopathes*, however, the polyps are distributed in a single linear series, so that his suggestions on this point require verification.

Habitat.—Off Cape Moresby, New Guinea, in 4 fathoms (Brit. Mus.).

Cirripathes anguina, Dana.

Cirrhipathes anguina, Dana, Zooph., p. 577, pl. lvi. fig. 1.
? *Palmijuncus anguinus*, Rumphius.
? *Cirrhipathes Sieboldi*, Blainville, Manuel d'Actinol., p. 512.
Antipathes sp., Gray, Proc. Zool. Soc. Lond., 1857, p. 114, pl. vi. (Radiata).

"Stem quite simple, somewhat spirally flexuose, polyps greenish, scarcely beaked; tentacles fuscous at base, axis with faint articulations at long distances, spines rather remote, compressed, subacute" (Dana, *op. cit.*). Dana remarks that this species resembles *Antipathes spiralis*, Pallas, but the polyps are not properly beaked, and the spines are more distant, stouter, and hardly acute. The axis has distinct nodes every three or four inches. Stem, six feet long in five feet of water, twisted so as not to reach the surface. Polyps one-sixth of an inch apart. His figures show the polyps to be more distant than in *Cirripathes propinqua* and to lack the prominent oral prominence of other types. The spines, as figured, are short, stiff, and slightly hooked upwards. They appear closely packed in irregular transverse series, and all are of the same size.

This species, or at any rate the *Palmijuncus anguinus*, Rumph., which Dana regarded as probably identical, was included by Pallas as a form of *Cirripathes spiralis*. I have made a careful comparison of a number of specimens in various museums, in order, if possible, to throw some light on the subject. Between the truly spiral type (which, so far as my observations go, appears to be rare) and the non-spiral, with a straight stem, there appear to be a number of flexuose and contorted forms which may be so many individual variations. Unfortunately, the size and arrangement of the spines vary considerably in different individuals, and it appears as if satisfactory specific characters can only be obtained from an examination of well-preserved polyps. The distinctly spiral form differs in several points from the straight or flexuose specimens and is here regarded as typical *Cirripathes spiralis*. The others, which do not agree with the characters of *Cirripathes propinqua*, are to be provisionally regarded as *Cirripathes anguina*, Dana. The stem may or may not present alternate dilations and contractions; it is apparently never twisted into regular spirals and the spines are not distinctly shorter on one aspect than on that opposite to it.

In the specimen from Seychelles described and figured by Gray in 1857 (38) the polyps, though dried, are distinctly seen on some parts of the stem, where about four are arranged to each centimetre in the length of the stem. There are three very fine specimens of this species in the British Museum from Billiton. The longest measures over 3·6 m. in length. In nearly all the specimens which have come under my notice the stem is relatively thick (5 to 10 mm.). The Ceylon specimen, which I doubtfully refer to this species (B. M., Reg. No. 82. 7. 21. 3.), is more distinctly tapering than the majority of specimens, and, in its upper portion, the spines are stronger and less numerous. It measures 1·8 m. in length and has a diameter of 8 mm. at the base and 2 mm. at the apex.

Habitat.—Fiji, 5 feet (Dana); Red Sea, (Klunzinger); Seychelles (Stephens), Brit. Mus.; Billiton (Bolsius), Brit. Mus.; Ceylon (Ondaatje), Brit. Mus.

Cirripathes spiralis (Linn.), Blainv., *non* Pourtalès (Pl. XII. fig. 10).

Gorgonia spiralis, Linnæus, Syst. nat., ed. x.
Gorgonia abies, var. *spiralis*, Linnæus, *op. cit.*, ed. xii.
Antipathes spiralis, Pallas, Elench. Zooph., p. 217; Ellis and Solander, Zooph., p. 99, pl. 19, figs. 1–6; Esper, Pflanzenth., pt. iii., p. 154, pl. 8; Lamouroux, Polyp. flex., p. 373; Expos. méthod., p. 31, pl. 19, figs. 1–6; *non* Pourtalès, Bull. Mus. Comp. Zoöl., vol. vi. p. 114.
Cirrhipathes spiralis, Blainville, Manuel d'Actinol., p. 512, pl. 88, fig. 2; Dana, Zooph., p. 376; Milne-Edwards, Coralliaires, vol. i. p. 313; Gray, Proc. Zool. Soc. Lond., 1857, p. 290.

"A simplissima attenuata, flexuoso-spiralis, spinulis seriatis scabra.

"Est *culmus*, simplicissimus, longissimus, crassitie fere calami scriptorii, *teres*, extremo lentissime attenuatus, imo subflexuosus, deinde spirali volumine pergens. *Superficies* nitidula punctis seu spinulis per longitudinales series digestis hispidus. *Substantia* atra, cornea, rigidissima fragilisque; medullari tubulo totum culmum transcurrente" (Pallas, *op. cit.*). In addition to the spiral form, which alone constitutes this species, Pallas appears to have included the *Palmijuncus anguinus*, Rumph., a flexuose but non-spiral species. Blainville was the first to doubt the identity of the two forms; later, Dana identified his Fiji specimens as probably the *Palmijuncus anguinus*, Rumph., and accordingly named it *Cirripathes anguina*. The *Antipathes spiralis*, E. and S., is perhaps the true spiral species and their figures have been copied by subsequent authors. On account of there being a considerable number of species with an elongated unbranched axis, older authors appear to have confused several species under the same name, and in the case of *Cirripathes spiralis* we have a number of records of localities, which certainly require verification before they can be fully accepted. Such are the Mediterranean (Baker), and Norway (Brünnichen). In the British Museum Collection there are two specimens which I regard as belonging to this species, one from Ceylon and the other from Kurrachee. The collection also contains another spiral form, different from those I have regarded as the type, and also from the *Antipathes spiralis*, Pourtalès. This I have named *Cirripathes diversa*, but as older authors have not given us exact details of the arrangement of spines, which, in the absence of polyps, form the only guide to identification, I cannot be sure that the species selected by me to represent *Cirripathes spiralis*, is really the form described by Pallas. In the Ceylon specimens, though dry, it is easy to make out that the polyps have been distributed all around the axis and not in a single longitudinal series. The height of the specimen, not allowing for the spirals, which are close and well marked, is 90 cm.; the diameter at the base a little under 3 mm.; and at the tip 1·6 mm. The spirals are wound from left to right. The Kurrachee specimen is about 76 cm. long

The spirals are also wound from left to right; they are somewhat irregular, about five in three centimetres, and about 1·5 cm. in diameter. In this specimen the polyps are partly preserved, but not so distinctly as in the one first described. Ellis mentions a specimen seven feet long with a stem "not thicker at the base than the quill of a hen's feather"; the one which he figures was two feet long, the thickness of a writing pen, and curled and twisted in a remarkable manner. On stems of medium diameter the spines are arranged in distinct spirals, passing from right to left, but on the basal portion of a stem, and on those which are relatively thick, the marked spiral arrangement is lost. Pl. XII. fig. 10 represents what I regard as the typical arrangement. In addition to the spiral arrangement, the spines form longitudinal rows, ten or eleven of which may be counted from one aspect. The members of a row are of equal size, but the rows on the outer margin of the spiral stem are longest, and there is a gradual diminution in size towards the inner margin where the spines are quite short and pointed. The longest spines are separated by an interval which is about equal to their length, and this distance corresponds to the interval between the spirals. The longest spines are conical, only slightly tapering, and have a blunt apex.

A specimen in the Museum of the Royal College of Surgeons of London (C 45 of the Catalogue) is the only other specimen I have seen which appears referable to this species. The stem is about 2·5 mm. thick, and consists of about twenty-seven spiral coils which average 2·5 cm. in diameter. The apical portion of the stem is not preserved, and the spines have lost the regular spiral arrangement in the upper portions of the specimen. In the Copenhagen Zoological Museum I found two or three specimens labelled *Cirripathes spiralis*, which, however, do not belong to that species as here defined, but approach Dana's *Cirripathes anguina* closely. The fact that I have found only one truly spiral specimen amongst the older collections to which I have had access—the British Museum specimens have been received during the past few years—makes it possible that the species here described as *Cirripathes spiralis* may not be the same as that of Pallas, Ellis, &c. There appear to be no means of definitely deciding the question at present.

Habitat.—Indian Ocean (Pallas); Molucca (Ellis); ? Norway (Brünnichen); ? Mediterranean (Baker); Ceylon (Ondaatje), Brit. Mus.; Kurrachee (Murray), Brit. Mus.; East Indies (Stokes), Mus. Roy. Coll. Surg. Lond.

Cirripathes ? paucispina, n. sp. (Pl. XII. fig. 6).

Stem simple, only slightly tapering. Sclerenchyma light brown, with six longitudinal rows of distant short spines. Diameter of stem 1·5 mm.; zooids not observed.

The type specimen of this species is in the British Museum Collection (Reg. No. 73.4.26.1), and consists of two fragments measuring together about 23 cm. The

sclerenchyma is in thin concentric layers, and has a light muddy brown colour, similar to that of other species in parts where the sclerenchyma is very thin. In this species the sclerenchyma is of normal thickness in proportion to the diameter, but the colour, in mass, is uniformly pale. The surface is glossy, and recalls the appearance of mica. The spines are short, very distant, arranged in six longitudinal rows, four of which may be seen from one aspect. They are short, conical, with a blunt apex which is slightly rugose. The spines are separated by an interval equal to three to three and a half times their length; some stand out at right angles to the axis, others are slightly hooked upwards; a spiral arrangement is not well marked (Pl. XII. fig. 6). In the colour of the axis and scarcity of spines, this species differs from all other unbranched forms yet described. Whether it really belongs to this genus can only be decided when its zooids are known. The specimen was presented to the British Museum by Gassiott, it is not known from what locality.

Cirripathes? flagellum, n. sp. (Pl. XII. fig. 13).

Stem simple, very long, not spirally twisted, scarcely sinuous. Stem 3·5 m. long, diameter at base 6 mm., at tip 3 mm., but the apex of the corallum is not preserved. The cœnenchyma has dried on the axis, and no polyps are preserved, but lighter patches here and there lead one to suppose that they may be distributed all around the stem; this point must, however, be left open for further investigation. This form agrees with *Cirripathes diversa* in having two kinds of spines, and in this respect differs from all other known species of the genus. In habit and size it comes near *Cirripathes anguina*, Dana, and *Cirripathes propinqua*, but differs altogether from either in the arrangement of spines.

The long spines are conical, more elongate and pointed than in any other species of the genus; most of them are covered near the apex with very small rounded prominences. The large spines show an imperfect spiral arrangement, which is never well marked. They are separated by variable intervals, which, however, rarely equal the length of a spine. The smaller spines are distributed in irregular rows between the larger ones; they are very slender, and relatively elongate, attaining about half the length of the stouter series.

The type specimen is in the Collection of the British Museum (Reg. No. 88.4.10.2).

Habitat.—Ceylon (Ondaatje).

Cirripathes? diversa, n. sp. (Pl. XII. fig. 12).

This species is similar in habit to *Cirripathes spiralis* (Linn.), but differs essentially in the spines, which are of two very distinct sizes, the smaller ones filling in the spaces between the larger.

The type in the British Museum (Reg. No. 82.7.31.4) is from Ceylon, and is quite devoid of polyps, so that I cannot say with certainty whether it belongs to the genus *Cirripathes*, as modified in the present Memoir, or to the new genus *Stichopathes*. The specimen is 30 cm. long, not following the spirals, and about 1·5 mm. in diameter at the base, in outward appearance only differing from the Ceylon specimen of *Cirripathes spiralis* (Brit. Mus. Reg. No. 82.7.13.2), in being shorter and more slender from the base upwards. The spines, however, show the following arrangement. A number of stout cylindrical spines with a blunt apex are arranged probably in a dextrorse spiral; these are subequal in length, and arranged also in longitudinal rows, about twelve of which may be seen from one aspect. The members of a row are about two and a half lengths apart. The interval between the large spines is not smooth, as in *Cirripathes spiralis*, but is filled in by a large number of very short triangular spines projecting little beyond the general surface of the sclerenchyma, but each with a sharp point.

Habitat.—Off Galle, Ceylon (Ondaatje), Brit. Mus.

Genus *Stichopathes*, n. gen.

Cirrhipathes (*pars*), Auctt.
Antipathes (*pars*), Pourtalès, Gray, &c.

Sclerobasic axis forming a long, flexible, sometimes spirally curved rod, simple, and without branches of any kind.

Polyps well developed, situated on one side of the stem only, and having six very long digitiform tentacles. The polyps are sometimes alternately large and small, in which case the smaller ones are hidden by the long tentacles of the larger polyps. "The cœnosarc on the back of the branch (stem) shows transverse canals more transparent than the rest, in the space between successive polyps" (Pourtalès, **71**, p. 114). The histological structure of the species to which Pourtalès here refers, *Stichopathes pourtalesi*, n. sp., is not known, but his observation would seem to show that this species forms a link between the genus *Cirripathes* and other Antipathinæ. I have been induced to form this new genus in consequence of what Pourtalès says about his *Cirrhipathes spiralis* (Pourt. *non* Pall.), and in order to distinguish those unbranched forms of Antipathinæ having the polyps on one side of the axis only, from those which, as in the genus *Cirripathes*, have them distributed spirally all around the stem. I am unable to give any further information on the structure of the polyps in question, as this genus is not represented in the Challenger Collection, and the only species in the British Museum which I could with certainty refer to it, are not preserved in spirit, so that the polyps are not available for study.

Synopsis of Species.

1. Stem long, slender, spiral; spines small, conical, arranged in irregular sinistrorse spirals, ... *pourtalesi*, n. sp.
2. Stem long and slender, sinuous but not spiral, scarcely tapering; spines simple, triangular, with further growth becoming bifid and ultimately double, . . *gracilis* (Gray).
3. Stem slender, not spiral, distinctly tapering; spines numerous, short, triangular, much compressed, directed upwards, and arranged in steep sinistrorse spirals,. . *echinulata*, n.sp.
4. Stems slender, relatively short, several from one base; spines small, arranged in regular verticils, ... *desbonni* (D. & M.).
5. Stem elongate, slender, tapering; spines short, conical, somewhat compressed, arranged in dextrorse spirals on younger portions of the axis, . . . *occidentalis* (Gray).
6. Stem slender, scarcely tapering; spines very large, slightly bent upwards, arranged in irregular sinistrorse spirals, ... *filiformis* (Gray).
7. Stem slender, slightly tapering; spines large, distinctly papillose, longer on one side of the axis than on the other, ... *lütkeni*, n. sp.

Stichopathes pourtalesi, n. sp.

Antipathes spiralis, Pourtalès (*non* Pall.), Bull. Mus. Comp. Zoöl., 1880, p. 114, pl. 3, figs. 5, 25, 26.

Antipathes Desbonni, Pourtalès (*non* D. & M.), Bull. Mus. Comp. Zoöl., vol. v. p. 209; Illustr. Cat. Mus. Comp. Zoöl., No. viii., 1874, p. 46.

Stem very slender, wound nearly from the base into spirals, 10 to 20 cm. in diameter. The spirals are either from right to left or the reverse, and sometimes change in the same specimen. Spines short, triangular, compressed, and never in verticils but in quincunx. Longest specimens 3·2 m. long, and only 4 to 5 mm. in diameter at the base. The polyps are alternately large and small, having long digitiform tentacles much longer than has been figured for any other species (*cf.* Pourt., *loc. cit.*, pl. iii. figs. 25 and 26). The figures show the polyps and tentacles as frequently disposed, the larger polyps alone being visible; the smaller ones are seen only in profile view. At other times (probably owing to the action of spirit) the tentacles are much shortened and stiffened, and stand out like those of *Antipathes arborea*, Dana. The cœnenchyma on the back of the stem shows transverse canals more transparent than the rest in the spaces between successive polyps.

In an earlier notice of this species (**64**, p. 209) Pourtalès speaks of the axis having six rows of spines of which the polyps cover four. (In his later figures of the spines they are shown arranged in an irregular spiral, five or six of a series being visible from one aspect.) The polyps are large and crowded, alternately but not regularly large and small. "Eggs were found in one of the larger, thus rendering it probable that they and the smaller ones are of different sexes" (Pourt., *loc. cit.*, p. 209). The bearings of this point are discussed under Section II. of this Monograph. In the polyps near the base of the stem the tentacles become obsolete, although the mouth is plainly visible.

Pourtalès in his earlier notices referred this form to *Cirripathes Desbonni*, D. & M., but in 1880 he described both forms, which are very distinct. This, the spiral species, he referred to *Antipathes spiralis*, Pallas, suspecting, however, that it might differ, but having no means of comparison at the time. Both forms have a spiral habit, but this of Pourtalès has, in proportion to its length, a much more slender axis. It further seems very probable that in the spiral species, *Antipathes spiralis*, Pallas, the polyps are distributed spirally around the stem, in which case it comes under the genus *Cirripathes*, as modified in the present Memoir.

Habitat.—Off Sand Key, Florida, 45 fathoms. Very common, occurring at twenty-three stations and at depths from 45 to 878 fathoms, off Havana, Santa Cruz, Montserrat, Martinique, St. Vincent, the Grenadines, Granada, and Barbadoes.

Stichopathes gracilis (Gray) (Pl. XII. figs. 17–19).

Antipathes (*Cirrhipathes*) *gracilis*, Gray, Proc. Zool. Soc. Lond., 1857, p. 291.
? *Antipathes* (*Cirrhipathes*) *setacea*, Gray, Ann. and Mag. Nat. Hist., ser. 3, vol. vi. p. 311.

Gray's description of this species, consisting only of the words "slender, tapering, slightly spinose," is of no value whatever in the identification of the species. The specimen to which he referred is in the British Museum, its identity being made certain by the reference, "Madeira, Mason, 1857," on the label. This specimen appears to have been broken in two. The lower portion bearing the label, though not actually possessing the dilated base of attachment, is probably the lower part of the stem, being covered for three or four inches near the base by parasitic growths, and having a number of bivalve molluscs attached to the axis. This portion is contorted, not spiral, and is 75 cm. long, slightly tapering, and having a diameter of 2·5 mm. near the base. Another specimen, without label, which I take to be the upper portion of the type specimen, has the same wavy outline, and is 1·1 m. long. The diameter of the lower portion of this specimen agrees with that of the apex of the type. The diameter at the apex is only 0·45 mm., and if my surmise be correct, the whole specimen must have measured nearly 2 m. in length.

A more recent specimen (1863) from the same locality is nearly straight, 1·3 m. long, 3 mm. in diameter at the base, and 1·4 mm. at the apex. This specimen has the dilated base attached to a mass of broken shells, &c. In the lower portion of the stem the spines are arranged in seven rows, running almost longitudinally, but twisted in a very open spiral, which requires over three inches to complete one revolution of the axis. Still another specimen of this species is found in the British Museum Collection (Reg. No. 72.6.22.3), but whether regarded by Gray as a specimen of this species or of his *Antipathes setacea*, I am unable to say. (I have been unable to find Gray's type of *Cirrhipathes setacea*, which was described in 1860, from Madeira—the same locality as that in

which the present species occurs.) The specimen here referred to is attached by thread to a card, which also contains Gray's type of *Cirrhipathes setacea*, var. *occidentalis*. Both specimens bear a register number, but neither are named, the card simply bearing the inscription, "Madeira, J. Y. Johnson." This evidently cannot refer to the var. *occidentalis*, as that came from Turk's Island, West Indies. The other specimen may have been regarded by Gray as a specimen of his *Cirrhipathes setacea*, but certainly it cannot be the type, as the species was described in 1860, and the specimen in question was only received in 1872. This specimen, which is about 30 cm. long and 2 mm. in diameter at the base, agrees in every respect with the specimens of *Stichopathes gracilis*, here described. As I have no means of ascertaining what form Gray actually did regard as *Cirrhipathes setacea*, and as his description of the type contains no characters not applicable to this species, I have queried *Cirrhipathes setacea* as a probable synonym. His *Cirrhipathes setacea*, var. *occidentalis* evidently, from his description, differs very much from the type, and as I find the specimen to differ from any to which I have had access, I have raised it to the rank of a species, under the name *Stichopathes occidentalis* (Gray).

All the Madeira specimens here described agree in having a relatively slender non-spiral axis, on which the polyps are placed in a single longitudinal row.

The spines vary very much in size, shape, and relative frequency in different portions of the axis, but the arrangement on portions of the same diameter is practically the same in the various specimens referred to. In slender portions of the stem the spines are arranged spirally, and also in longitudinal rows (Pl. XII. fig. 17). They are triangular, compressed, and stand out at right angles to the stem, those in one row being about two lengths apart. Most are simple, and have a sharp apex, but a few are forked at the tip. In somewhat older and thicker portions of the stem (Pl. XII. fig. 18) the arrangement of spines is less regular. A few are simple and irregularly arranged, but the majority form double spines, having two divergent apices united by a common swollen base. This appearance is presumably brought about by the further deposition of horny lamellæ over spines which had already become bifid at the tip, each new layer tending to make the bifid character more pronounced. In still older and thicker portions of the stem (Pl. XII. fig. 19), by a still greater increase in the thickness of the sclerenchyma, the bases of the bifid spines become covered over, and in their place a number of simple spines are to be found arranged in pairs close together, each pair having apparently been derived from a primitively simple spine by the process indicated. The majority of the spines are now simple, but some are short and broad, having the apex divided into a number of processes giving a serrate appearance.

Habitat.—Madeira (Brit. Mus.).

Stichopathes echinulata, n. sp. (Pl. XII. fig. 9).

Corallum slender, elongate, distinctly tapering; spines much compressed, arranged in very steep spirals.

The type of this species is in the British Museum (Reg. No. 82.2.21.5), and is from Mauritius. The stem is 1 m. long, and 2·5 mm. in diameter at the base. Amongst the more slender forms it is more distinctly tapering than any with which I am acquainted. The specimen is dry, and the polyps are preserved on a portion of the axis, where they are distributed in a single row. This species comes nearest to *Stichopathes occidentalis* (Gray) in the form of the spines. They are short, triangular, much compressed, and directed upwards. They are arranged in subregular spirals, which are steeper than those of *Stichopathes occidentalis*, and apparently are sinistrorse instead of dextrorse. The spines also form regular longitudinal rows, nine or ten of which may be counted from one aspect. The members of a row are about three lengths apart.

Habitat.—Mauritius (Brit. Mus.).

Stichopathes? desbonni (D. & M.).

Cirrhipathes Desbonnii, Duchassaing and Michelotti, Mem. Acad. Torino, ser. 2, t. xxiii. p. 142; Pourtalès, Bull. Mus. Comp. Zoöl., 1880, p. 114, pl. iii. figs. 6, 7.

"Species lenta, nec flexuose spiralis, simplex, filiformis, caudata, nigra, spinis minutis, confluentibus" (D. & M., *loc. cit.*, p. 142). To this scanty description I am able to add the later and more definite observations of Pourtalès who identified it amongst the collections made by Agassiz during the "Blake" Expedition to the Caribbean Sea. This form was obtained growing in clusters, a dozen or more stems from an expanded base. Each stem is undivided, slender, straight, or slightly bent, but never in a spiral, and hollow near the apex. The spines are small and rather blunt, arranged in regular verticils, of which there are about thirty to a centimetre, each verticil being composed of about twenty spines. Vertically the spines are disposed in straight rows, not winding spirally round the stem as in other forms. On the older parts of the stem the verticils lose their regularity, but can always be recognised. The tips of the stems are membranous, and collapsed when dry, being thin and hollow, with the spines already quite distinct (*cf.* Pourt., *loc. cit.*, pl. iii. figs. 6, 7). Longest stem 70 cm., diameter at base 1·5 mm. Polyps not observed.

Habitat.—Guadeloupe (Duch. & Mich.); off Montserrat, 88 fathoms (Pourtalès).

Stichopathes? occidentalis (Gray) (Pl. XII. figs. 7, 8).

Cirrhipathes setacea, var. *occidentalis*, Gray, Ann. and Mag. Nat. Hist., ser. 3, vol. vi. p. 311.

Gray's type of this form is 2·74 m. long, very slender and tapering; the base is 2 mm. in diameter, and the apex 0·2 mm. The whole stem is like a slender whip lash, and

shows no signs of spiral curvature. Possibly the polyps are on one side of the axis only, but I could not make sure of this as the specimen is dry and almost entirely void of polyps. It differs from *Stichopathes desbonni* (D. & M.), from the same area, in having the spines arranged in close spirals and longitudinally in linear series, instead of in verticils, and from *Stichopathes pourtalesi*, in having the axis straight instead of spirally twisted, and also in the arrangement of the spines, which seems most nearly allied to that of *Stichopathes echinulata*.

The spines are short and conical, but somewhat compressed. In more slender portions of the specimen they are arranged in dextrorse spirals which are about twice the length of a spine apart. Nearer the base the spiral arrangement is lost, and the spines are thicker and stand out horizontally.

Habitat.—Off Turk's Island, West Indies (Todd), Brit. Mus.

Stichopathes? filiformis (Gray) (Pl. XII. figs. 23, 24).

Cirrhipathes filiformis, Gray, Ann. and Mag. Nat. Hist., ser. 4, vol. ii. p. 444, 1868.

"Coral very slender, thread-like, of equal diameter from end to end, pale brown, with crowded spinules on the surface; the spinules are conical, nearly transparent and spread out nearly horizontally from the axis" (Gray *loc. cit.*).

Gray's type is in the British Museum and was found amongst some reptiles, &c., purchased of Mr Higgens, from Australia. The specimen is in spirit, and measures 52·5 cm. in length, and 0·6 mm. in diameter at the base. The specimen is attached to part of a shell by a dilated base, and is only very slightly tapering. No polyps are preserved. Another specimen, obtained by Dr. Coppinger of H.M.S. "Alert" off N.E. Australia, is also without polyps. The stem is subequal throughout or only slightly tapering; the base is not preserved. This specimen measures 1·1 m. in length and has a diameter of 1·5 mm. Four other small specimens in the British Museum from St. Helena appear to be young forms of this species. They vary from 12 to 18 cm. in length; the largest, which is attached to a bullet, is 0·6 mm. in diameter at the base.

The spines are relatively large, conical, somewhat compressed, and slightly bent upwards. In shape and size they come near to those of *Antipathes dichotoma*, Pallas, but are much more numerous. They are arranged in irregular sinistrorse spirals, which are rather steep. The spines in one longitudinal row are about one and a quarter to one and a half lengths apart. In the young St. Helena specimens a spiral arrangement of the spines is not noticeable, but otherwise they appear to agree with the type specimen.

Habitat.—Australia (Gray); N.E. Australia (H.M.S. "Alert," 1881); St. Helena, in 10 fathoms and under (Lieut. Turton), Brit. Mus.

Stichopathes? lütkeni, n. sp. (Pl. XII. figs. 28, 28*a*).

Cirrhipathes filiformis, n. sp., Lütken, MS.

Stem about 80 cm. long, slightly tapering; diameter 2 mm. at base, 0·7 mm. at apex. The lower portion of the stem is nearly straight, the upper is flexed and twisted into three irregular open spirals, the terminal ones being 7 cm. in diameter. This species bears a general resemblance to *Stichopathes filiformis* (Gray), and in the subspiral growth of the stem is intermediate between that form and the truly spiral species, such as *Stichopathes pourtalesi*, n. sp., and *Cirripathes spiralis* (Linn.). It is probable that the amount of flexure, &c., may vary in different specimens. This species is, however, readily distinguished by an examination of the spines, which are slightly but distinctly papillose, a character not found in any other species of this or the preceding genus hitherto described. The spines, as in *Cirripathes spiralis* and some other species, are longer on one side of the axis than on the other. The short spines are triangular, somewhat compressed, and have a sharp apex; the longer ones are conical, only slightly tapering and have a blunt apex. Each is covered for almost its whole length with fine granular papillæ. The spines are arranged in irregular spirals and also in longitudinal rows, eight of which are visible from one aspect in the portion figured (Pl. XII. figs. 28, 28*a*). In the lower part of the stem the spines are arranged in longitudinal rows, which turn very gradually round the stem. They are here short and triangular, and apparently subequal. The polyps have not been observed.

Habitat.—West Indies. The type is in the Zoological Museum of the University of Copenhagen.

Section II. RAMOSÆ, corallum branched.

Genus *Leiopathes* (Gray), M.-Edw. and Haime, *emend.*

Antipathes (*pars*), Esper, Pflanzenth.; Lamarck, Hist. nat. anim. sans vert., t. ii.; Dana, Zooph.; Gray, Proc. Zool. Soc. Lond., 1832, p. 41; Duch. and Mich., Mem. Acad. Torino, ser. 2., t. xxiii.; Pourtalès, Cat. Corals Harvard Mus., No. iv., 1871; Bull. Mus. Comp. Zoöl., 1880.

Leiopathes (*pars*), Gray, Synop. Brit. Mus., 1842, p. 135; M.-Edw. and Haime, Brit. Foss. Corals, Introd., p. lxxiii.; Archives d. Mus. Paris, t. v., 1851, p. 176; Gray, Proc. Zool. Soc. Lond., 1857, p. 289; M.-Edw., Coralliaires, t. i., 1857, p. 322.

The polyps possess three pairs of primary mesenteries and three pairs of secondary ones. One pair of secondary mesenteries is very short, and none of them extend into the lower section of the cœlenteron. The sagittal tentacles are usually longer and thicker than the other four. The corallum is dendriform, and the ultimate branchlets are always very slender. The spines are very short and never very numerous. They

may be absent altogether from the older portions of the corallum, which is then smooth and polished.

This genus differs from all other known Antipathidæ in possessing twelve instead of ten mesenteries, as well as in several other points. Gray's name has been retained for it on the presumption that *Antipathes glaberrima* (Esper), formed the type of his genus, which, as already stated, is uncertain. The other species, included by Milne-Edwards and Gray in the same genus, have no place in it as now modified. A discussion of their probable position will be found in the first section of this Report. The name *Leiopathes* was first suggested by Gray, but the first definition of the genus is due to Milne-Edwards and Haime.

The arrangement of *Antipathes lenta*, Pourt., under this genus is only provisional, as I have not had an opportunity of examining the polyps. Judging from the description and figures given by Pourtalès it appears more closely allied to *Leiopathes glaberrima* (Esper), than to any other species of Antipathidæ with which I am acquainted.

Leiopathes glaberrima (Esper), M.-Edw. (Pl. IV. figs. 8, 9; Pl. XII. figs. 21, 22; Pl. XV. figs. 3–5).

Antipathes glaberrima, Esper, Pflanzenth., pt. ii. p. 160, pl. 9; Lamk., Hist. nat. anim. sans vert., t. ii. p. 306; Dana, Zooph., p. 585; Pourtalès, Bull. Mus. Comp. Zoöl., 1880, p. 118, fig. 2.

Antipathes dichotoma, Gray (*non* Pallas), Proc. Zool. Soc. Lond., 1832, p. 41.

? *Leiopathes glaberrima*, Gray, Synop. Brit. Mus., 1842, p. 135; M.-Edw. and Haime, Distrib. méthod. (Monogr. d. polypiers foss. d. terr. palæoz.), Archives d. Mus. Paris, t. v., 1851, p. 176; Gray, Proc. Zool. Soc. Lond., 1857, p. 290.

Leiopathes glaberrima (Esper), M.-Edw., Coralliaires, t. i. p. 322.

? *Antipathes dissecta*, Duch. and Mich., Mem. Acad. Torino, ser. 2, t. xxiii., p. 142.

Antipathes dissecta (Duch. and Mich.), Pourtalès, Cat. Corals Harvard Mus., No. iv., 1871, p. 53.

Corallum large, irregularly branched, with long crooked branches of more or less elliptical section. At other times the growth is more regular, giving a dendritic form not unlike a flattened ash. The main stem is 2 or 2·5 cm. in diameter, jet black and polished; the branches gradually taper, and all have the same polished smooth appearance as the stem. The ultimate branchlets are slender, laxly pinnate, pale brown in colour, and covered with short distant spines (Pl. XII. figs. 21, 22). Height of the corallum 1 m. or more. There is a fine specimen of this species in the British Museum.

I am indebted to Dr. Dohrn, of the Naples Zoological Station, for a few terminal twigs of this species, on which the polyps are well preserved. The specimens had been killed in osmic acid, so that the ectoderm is black. In portions not affected by the acid the colour in spirit is a dirty yellow. The mode of branching near the apex of the corallum is lax and irregular, the ultimate pinnules being usually at right angles to the branchlet from which they arise. One fragment 5·5 cm. long bears eight branchlets,

most of which bear one or two pinnules at right angles. The branchlets are 1 to 2 cm. apart and from 1 to 3 cm. long. They are quite irregularly arranged and may spring from any portion of the circumference. The sclerenchyma in such terminal portions of a colony is from 0·5 to 0·7 mm. thick.

The zooids vary very much in size, a feature which evidently depends on age. They are arranged at irregular intervals along the sclerobasic axis, usually from one to two diameters apart, and not so strictly confined to one aspect of a branch as in many other forms. The zooids are about 1 mm. in diameter and rarely project above 0·5 mm. beyond the surface of the cœnenchyma. The mouth is usually, but not invariably, elongated in the sagittal axis; the whole surface of the peristome is dome-shaped, but there is usually no special elevation of it on which the mouth opens. The tentacles are subcylindrical and arranged in pairs. Those which terminate the sagittal axis are usually rather longer and thicker than the others (1 to 1·5 mm.). They are also inserted at a lower level, and in spirit specimens almost always stand out horizontally. The two lateral pairs are short and thick, and in adult zooids are usually bent inwards towards the mouth. In young specimens they project vertically. Owing to the fact that in this genus new zooids may be added at any point, as dilations of the cœlentera of adult zooids, the size of the various individuals on a branch is most variable. Although large and small zooids are arranged alternately in some instances, the usual arrangement is by no means so regular (Pl. IV. figs. 8, 9).

Habitat.—Mediterranean (Esper); in 135 fathoms, Naples Zool. Stat. West Indies.—Off Alligator Reef in 110 fathoms; off Sand Key in 125 fathoms; off Coffin's Patches in 195 fathoms; off Bahia Honda in 324 fathoms (Pourtalès).

Leiopathes? *lenta* (Pourt.).

Antipathes lenta, Pourtalès, Illustr. Cat. Mus. Comp. Zoöl., No. iv. 1871, p. 55; *op. cit.* No. viii., 1874, p. 47; Bull. Mus. Comp. Zoöl., 1880, pl. iii. fig. 4.

The following is a summary of the description given by Pourtalès :—

Mode of branching, unknown. Pinnules, very long and slender, like thin horse-hair, not regularly pinnate; spines in number intermediate between those of *Parantipathes larix* and *Antipathella subpinnata*, as figured by Lacaze Duthiers, but somewhat longer and straighter than in either. (? See description of figure.)

Polyps of same type as in *Leiopathes glaberrima*, but very much smaller and more distant; longitudinal and transverse diameter more disproportionate than in *Aphanipathes humilis*, and the tentacles show more tendency to arrange themselves in two parallel rows. Alternate large and small polyps, though not regular, are quite noticeable, and the disproportion in size is very great. Only a few branchlets were obtained, some ten to twelve centimetres long without much diminution in diameter.

I am at a loss to know where to place this species. Pourtalès first states that the polyps are of the *Antipathes dissecta* type (and in a later paper announces that the specimens which he had regarded as *Antipathes dissecta* really belonged to *Antipathes glaberrima*, Esper), which is distinctly rounded and radiate externally, and then goes on to call attention to the fact that the polyps are more elongate than in *Antipathes humilis*, which has the tentacles arranged in an oval.

On account of the fragmentary character of the specimens obtained it is difficult to suggest a relation to other species, but the delicacy of the pinnules and irregularity of branching would seem to indicate a relationship to *Leiopathes glaberrima* (Esper). The spines of the two species are of a similar type. In the figure given by Pourtalès the spines are represented as small, distant, and somewhat triangular, arranged in lax, irregular, sinistrorse spirals. Three or four longitudinal rows are visible from one aspect, the members of a row being about three lengths apart.

It should, however, be noted that in the original description, published in 1871, the spines are stated to be somewhat longer and straighter than those of either *Parantipathes larix* or *Antipathella subpinnata*, as figured by Lacaze Duthiers, but in the figure given in his latest paper (1880) they are represented as very short, with the characters given above.

The polyps have a general resemblance to those of *Leiopathes glaberrima*, but the mouth opens on a large, circular oral disc similar to that of [*Antipathes*] *picea*, Pourt.

Habitat.—Off Carysfoot Reef, in 35 fathoms; off Tortugas, in 37 fathoms; off Barbadoes, in 100 fathoms.

Genus *Antipathes*, Pallas (*emend.*).

Antipathes (*pars*), Pallas, Elenchus Zoophytorum, p. 205; Milne-Edwards, &c., &c.

Corallum shrub-like, without confluence of branches. Polyps large, rounded or slightly oval; tentacles radiating, those in the sagittal axis springing from near the middle of the polyp, the other two pairs from the margin of the peristome. The tentacles are relatively long and thick, those limiting the sagittal axis being longer than the others. There are ten mesenteries in the oral cone and six below. The reproductive organs are contained in a specialised band of tissue attached to the stomodæum and body-wall. The ectoderm, particularly that of the tentacles, is papillose, each papilla being filled in its central portion with a bundle of nematocysts.

I have taken *Antipathes dichotoma*, Pallas, as the type of this genus, it being the only species described by Pallas of which I have been able to study the structure of the polyps.

Synopsis of Species.

1. Corallum large, laxly branched, irregularly dichotomous; spines large, sub-triangular, much compressed; the upper margin extends subhorizontally, ... *dichotoma*, Pall.

(2–3. Definite specific characters for *Antipathes arborea*, Dana, and *Antipathes fœniculacea*, Pallas, cannot be given at present).

4. Corallum large, densely branched, resembling the Broom; the whole gradually tapering towards the apex; spines short, thick, and blunt, often papillose, . . *virgata*, Esper.
5. Corallum large, spreading, with very long slender branchlets; spines similar to those of *Antipathes dichotoma*, but more numerous and slender, . . . *lentipinna*, n. sp.
6. Corallum small, slender, with repeatedly forked filiform branches; spines short, sub-conical, with a sharp apex, ... *furcata*, Gray.
7. Corallum very laxly branched, with distant subhorizontal branches; branchlets few and rarely lateral; spines large and thorn-like, without spiral arrangement, . . *mediterranea*, n. sp.

Antipathes dichotoma Pallas (*non* Gray) (Pl. XII. fig. 16; Pl. XIII. figs. 1, 9; Pl. XIV. figs. 1, 5, 6).

Lithophyte, No. 9, Marsigli, Hist. phys. de la mer, pp. 105 and 168, pl. 21, figs. 101, 102, 103; pl. 40, fig. 179.

Antipathes dichotoma, Pallas, Elench. Zooph., p. 216; Dana, Zooph., p. 585; Milne-Edwards, Coralliaires, t. i. p. 319; *non* Gray, Proc. Zool. Soc. Lond., 1832, p. 41.

"Antipathes longissima, dichotoma, erecta" (Pallas, *loc. cit.*).

This species was described by Pallas from the information supplied in Marsigli's Histoire physique de la mer. Marsigli obtained his specimen in 140 fathoms, off Marseilles. The corallum is two feet high, and the diameter at the base only $1\frac{1}{2}$ lines. The stem is branched subalternately, the branches, which are not very open, being branched dichotomously at considerable intervals, the ultimate branchlets being usually divided in the same manner. The axis is covered with spines, and in addition a substance, which Marsigli compares to varnish, is developed on the stem, so that in the lower portion of the corallum the spines are almost obscured by it. On the branchlets where this substance is not so thick the spines stand out boldly.

Marsigli, who kept his specimen alive for several days in a jar of sea-water, gives the following account of the polyps:—

"Les extremitez des rameaux etoient entournées de petits globes de substance gelatineuse, et jaunâtre, n'ayant ancune union entr'eux, et y semblant plûtôt enfilez, comme des grains de chapelets dans de la foye . . . . . Je vis les petits globes prendre plusieurs figures oblongues, qui sur le haut avoient deux filamens tels que *B. B.*" In the figure referred to (*op. cit.*, pl. xxii. fig. 104), the polyps are shown in two longitudinal subopposite series, each zooid consisting of an oblong body, from the free margin of which a pair of thread-like tentacles take their origin. There must surely be considerable error in this account, both as regards the number of tentacles and the arrangement of the polyps.

I am indebted to Dr. Dohrn, of Naples, for a specimen of a Mediterranean form, which probably belongs to this species although it lacks the well-marked dichotomous form of branching figured by Marsigli. The specimen, which probably consists of the upper portion of a stem, is 29 cm. long and bears eleven branches in all, the terminal 9 cm. being simple. The branches vary from 3 to 16 cm. in length, and nearly all form a wide angle with the stem, in some cases almost a right angle, but all the longer branches after coursing out laterally or subanteriorly for some distance, are ultimately curved gracefully upwards. The branches are irregularly distributed, one pair are opposite, four are situated on the right lateral margin, and only one, the longest, on the left. Four others are placed on the anterior or antero-lateral margin of the stem, and pass out in various planes in front of the others. All are simple, with the exception of the largest, which bears two lateral branchlets on the inner margin, 1 cm. apart; these are 4 cm. long, and the lower one is 2·5 cm. from the base of the branch.

The stem in the lowest part preserved is 1·3 mm. in diameter; it and the branches gradually taper, there being no sudden diminution in diameter visible in any part of the specimen. The whole specimen is thickly clothed with polyps, which are well preserved.

The polyps on the stem are situated in a single longitudinal series on the anterior surface of the axis; on the lower portion of the branches, they are also placed on the anterior surface, but higher up, particularly on the longer branches, the linear series curves gradually outwards, so that near the apex it comes to be situated on the posterior surface.

The polyps are unusually large and generally subequal in size, but here and there a smaller and younger one is to be noticed between two large ones. Compared, however, with *Antipathes glaberrima*, Esper, and some other forms the polyps of this species are most regular in size. Usually about four polyps are distributed to each centimetre, but in parts they are not quite so close. The polyps of this species are larger than those of any other species of Antipathinæ which I have examined. A fully expanded polyp (in spirit) measures 7 mm. across the sagittal tentacles from tip to tip, and others, in which the tentacles are drawn together parallel with the body axis, are 4 mm. high. The polyps are rounded, with a very prominent oral cone; the tentacles are unequal in size, those situated at each end of the long axis of the mouth being long and usually much dilated. The other two pairs arise from the surface of the peristome; these are shorter, more slender, and frequently stand out perpendicular to the oral surface (Pl. XIII. fig. 1.).

The spines are strong and relatively distant. They have a length fully equal to half the diameter of the axis of a branchlet, and stand out almost horizontally. The base is broad, about two-thirds the length, and is usually much compressed. The spines are arranged spirally, but, from the regularity of their position, it is difficult to say whether the spiral winds from left to right or the reverse. The spines also form longitudinal

rows, six of which may be seen from one aspect. The members of a row are about two to two and a half lengths apart (Pl. XII. fig. 16).

This species appears to come near to *Antipathes fœniculacea*, Pallas, so far as can be ascertained from the description, but I am not aware that the branches are ever confluent. The Naples specimen appears intermediate in its mode of branching between Marsigli's type and the figure of *Antipathes fœniculacea* given by Wilkens and Herbst. The latter is also very similar to the *Fœnum marinum* of Rumphius, which Pallas regarded as probably identical with his *Antipathes fœniculacea*. The uncertainty as to identification can only be cleared up by a comparison of a number of specimens. Both types described by Pallas are from the Mediterranean.

Habitat.—Mediterranean. Off Marseilles, 140 fathoms (Marsigli); Naples Zoological Station, 110 fathoms.

Antipathes arborea, Dana.

Antipathes arborea, Dana, Zooph., p. 584, pl. 56, figs. 2, 2*a*; Milne-Edwards, Coralliaires, p. 319, pl. C_2, figs. 6*a*, 6*b*; Pourtalès, Bull. Mus. Comp. Zoöl., vol. vi. pl. 3, fig. 21.

Dana's description of this species is as follows :—

"Arborescent, lax and spreading ramose, three feet high; branches, subflexuous; axis throughout hispid, and branchlets long and slender, setiform, fragile; polyps, brownish-yellow, mouth prominent; polyps on branchlets, nearly in a single series."

Dana figures the polyp of this species, which appears to have a rounded contour, with thick elongate tentacles, the two lateral ones being larger and probably placed at a lower level, as in *Antipathes dichotoma*. Dana suggests that it has much the habit of *Antipathes dichotoma*, but is more spreading in its branches, a character which can scarcely be considered of specific value. The trunk at the base is half an inch thick, and gives off stout branches which subdivide quite irregularly. The spines have been figured by Pourtalès and appear to be shorter than those of *Antipathes dichotoma*, and not so numerous. They are subtriangular, much compressed, and stand out at right angles, but the apex is sometimes bent upwards. A spiral arrangement is not marked, but the spines are arranged in subregular longitudinal rows, the members of which are two and a half to four lengths apart.

Dana's species does not appear to have been met with by subsequent investigators, but, though it resembles *Antipathes dichotoma*, Pallas, very closely in mode of branching, the spines appear to afford sufficiently distinctive characters. The *Fœnum marinum* of Rumphius, judging from his figure, has a close resemblance to this form. Dana notes that *Antipathes compressa*, Esper, has the habit of this species so far as figured.

Habitat.—Sandalwood Bay, Fiji, 10 fathoms.

Antipathes fæniculacea, Pallas (*non* Esper).

Antipathes fæniculacea, Pallas, Elench. Zooph., p. 207.
? *Antipathes fæniculum*, Lamarck, Hist. nat. anim. sans vert., t. ii. p. 308 ; Lamouroux, Polyp. flex., p. 379; Encycl. méthod., t. iv. p. 71 ; Blainville, Manuel d'Actinol., p. 583 ; Dana, Zooph., p. 582; Milne-Edwards, Coralliaires, t. i. p. 318; Studer, Monatsber. Akad. Berlin, 1878, p. 548.

"*Antipathes* ramosissima, ramis setaceis, decomposito pinnatis. *Frutex* pedali sœpe major, in latum expansus, diffusus, tenuicaulis. *Truncus* in maximis calamo non crassior, ramosissimus, subdivisus. *Rami* inordinati, creberrimi, fere distichi, patentis, rigentesque, setacei ; *setis* distichis, sine ordine alternis vel subopposítis, aliquando ramosis pinnati. *Lignum* fruticis, ubi opacum, atrum extus tenerrime hispidum. Rami aliqui infracti quasi, cum contiguisque coaliti. *Tegumentum* mucosum, setaceis maxime ramis crassissimum, ex altero fruticis latere in nodulas per intervalla collectum, siccatumque ramulas nodosos sistens" (Pallas, *op. cit.*). Pallas thinks the *Fœnum marinum*, Rumphius, from the East Indies, may belong to this species, but his type came from the Mediterranean. So far as I am aware Studer is the only author who has recently recorded this species, but he adds nothing to the descriptions already given. His specimens (referred to *Antipathes fæniculum*, Lamarck) were obtained off Dirk Hartog, &c., West Australia, in 45 to 50 fathoms.

Lamarck's diagnosis has usually been followed, but it is not so complete as the original. One expression, viz., "ramulis ultimis setaceis *lævigatis*," renders it possible that he may not have had a truly spinose species before him. A comparison of the figure in the Herbarium Amboinense of Rumphius, with that in Wilkens and Herbst's translation of the Elenchus Zoophytorum (the original work was not illustrated), has led me to suppose that this species may be allied to *Antipathes dichotoma*, Pallas, if not identical with it. Both species are from the Mediterranean, which, so far, supports this view, but I have not seen any specimen agreeing with the definition of *Antipathes fæniculacea*. It is a much more densely paniculate form than *Antipathes dichotoma*, but, so far as the type of branching goes, if the figures referred to are to be relied on, it is the same in both cases. It may be, however, that an examination of the polyps and spines may show the two forms to be distinct. In the meantime, at any rate, it appears better to retain both names.

It should be noted that Pallas' type specimen came from the Mediterranean, but I am not aware that the species has since been recorded from that area. Lamarck's type, which, so far as can be ascertained from his description, does not appear to offer any essential points of difference, came from the Indian Ocean, as did also the specimen more recently recorded by Studer. It is therefore at present uncertain whether all belong to one species.

Habitat.—Mediterranean (Pallas); ? Indian Ocean (Rumphius, Lamarck); Dirk Hartog, West Australia, 45 to 50 fathoms, Mermaid Channel, 50 fathoms (Studer), "Gazelle" Expedition.

Antipathes virgata, Esper (Pl. XI. figs. 13, 14).

Antipathes virgata, Esper, Pflanzenth., (Fortsetz.), pt. ii. p. 8, pl. xiv.
Antipathes scoparia, Lamarck, Hist. nat. anim. sans vert., t. ii. p. 307; Milne-Edwards, Coralliaires, t. i. p. 319.

"Antipathes ramis dichotomis, ramulis strictis, virgatis, aculeatis" (Esper, *op. cit.*).

I have had considerable difficulty in deciding as to the identity of this species, on account of the fact that there are two specimens in the British Museum, which are specifically distinct, and both of which may be considered to agree with the original description of Esper. There seems no sufficient ground for supposing *Antipathes scoparia*, Lamarck, to differ specifically from *Antipathes virgata*, Esper, indeed, Lamarck himself gave Esper's name in the synonymy without a query. On the other hand, Esper's form was sent to him from the East Indies, whereas Lamarck gives the Mediterranean as the habitat of his form. I am not aware that any specimen, agreeing with the characters of *Antipathes scoparia*, Lamarck, has since been recorded from the Mediterranean.

Esper, in describing the spines of his species and comparing them with those of other forms, makes use of the following expression (*op. cit.*, p. 9):—"Sie sind höchstens, nur dichter angehäuft, und in gleichförmigere Reihen geordnet." On this account I have retained the form having the stouter and more closely packed spines under Esper's specific name *Antipathes virgata*, and have described the allied form as new. This course is in harmony with the identifications of Professor Lütken, who has specimens of what may prove to be both forms in the Copenhagen Museum.

The British Museum specimen referred to is 1·5 m. high, shrub-like, and densely branched, the long tapering branches being mostly directed upwards. The base is 2·5 cm. in diameter, and soon gives rise to a number of very long tapering branches, some of which, for a length of 5 to 8 cm., are spirally twisted. In other cases it appears as if a branch had become bifurcated for a short distance, the two parts being twisted together, and then above they become confluent again. The branching in the upper portion of the corallum is dichotomous, each branch bearing a number of elongate branchlets (15 to 50 cm.) mostly on one side. These arise at an acute angle and are mostly arched inwards so as to take an upward course. The whole corallum gradually tapers from base to apex, and there is no sudden diminution in diameter in passing from branch to branchlet in any part. In some cases a branchlet, after a short course of 8 or 10 cm., bends inwards and fuses with the branch from which it was derived, but, in most cases, the branches and branchlets are free. The sclerenchyma is black and glossy in all parts of

the corallum, and in the upper portion of the corallum has a diameter of 3 to 1·5 mm. The spines on the more slender branchlets are sometimes arranged in irregular and very steep spirals, which take a course of 4 or 5 cm. to complete one revolution of the axis, but, more usually, such a spiral arrangement is not marked. The spines are short, thick, and subcylindrical, having a blunt apex. They are usually crowded, about one length apart, and are arranged in regular longitudinal rows, six or seven of which may be counted from one aspect. In such cases a subregular spiral arrangement may be seen much closer than that previously referred to. In some portions of the corallum nearly all the spines are smooth but one here and there has a rough granulose apex (Pl. XI. fig. 13). In other portions all the spines are covered with irregular wart-like prominences (Pl. XI. fig. 14). In the Copenhagen specimen, already referred to, the base is very thick and gives rise at once to a number of spreading branches, as in a willow. These bear a number of very elongate branches, which arise from one side only and are generally close together. These, in turn, may bear another series of two to four branchlets of similar diameter, and usually on one side only. The height of the corallum is 1·1 m. The branchlets all ultimately take a subvertical direction. The spines are somewhat tuberculate in the newer portions of the colony; below they are arranged in relatively distant longitudinal rows. Lacaze Duthiers has examined the polyps of this species; they are large, and arranged in a single row on the upper surface of the branchlets.

Habitat.—Persian Gulf (Brit. Mus.); Indian Ocean (Esper); ? Mediterranean (Lamarck).

Antipathes? lentipinna, n. sp. (Pl. XI. fig. 19).

Corallum shrub-like, irregularly branched; stem and main branches relatively stout and black. Branchlets and pinnules slender and light brown. This species has a general resemblance to *Antipathes virgata*, Esper, but its branches are more spreading. A specimen in the British Museum is 1·37 m. in height. The stem and main branches are thick; the latter give rise to a large number of elongate slender branchlets, often 60 cm. in length. These bear a number of filiform pinnules, from 8 to 15 cm. in length, which are generally collected together near the upper portion of the branchlet, and are usually confined to one side. They are sometimes very numerous, and often occur with considerable regularity at intervals of 4 to 10 mm. The sclerenchyma is thick and black in the stronger portions of the corallum, but thin and golden brown elsewhere. The sclerenchyma of the elongate branchlets is sufficiently thick to retain its circular outline when dry, but that of the pinnules is merely membranous, and collapses under such conditions. The spines are arranged with considerable regularity on the sclerobasic axis in a spiral, which may be either dextrorse or sinistrorse. They are arranged very regularly in longi-

tudinal rows, seven of which may be counted from one aspect. The members of a row are about one length apart. The spines are much compressed, and have an elongated base; they are much longer and more slender than those of *Antipathes virgata*. They have a length about equal to half the diameter of a pinnule and taper to a sharp point. All the spines are simple, and no tubercles were observed on any of them.

This species is readily distinguished from *Antipathes virgata* by the marked difference in diameter between the branches and branchlets, the latter being very numerous, slender, and pale in colour. The spines of the two species are also quite different.

Habitat.—Jeddah, Red Sea, Capt. Wharton, H.M.S. "Fawn" (Brit. Mus.); Indian Ocean? "Galatea" Expedition (Copenhagen Mus.).

Antipathes? furcata, Gray (Pl. XI. fig. 2).

Antipathes furcata, Gray, Proc. Zool. Soc. Lond., 1857, p. 291.

"Coral, shrub-like, branched, repeatedly forked; branches, slender, elongate, filiform; stem, slender, short, and smooth" (Gray, *loc. cit.*).

Gray's type in the British Museum appears to me to represent only the apical portion of a branch with its branchlets of some large species allied to *Antipathes virgata*, Esper. The whole specimen is about 16 cm. high. The stem (?) is very slender and curved somewhat to one side; it bears a number of elongate bristle-like branches, all directed subvertically, and reaching about the same height. The branches give off secondary branches at irregular intervals, frequently from one side only; the lower ones bear a third series of branchlets, usually on one side only, giving rise to the "repeatedly forked" arrangements referred to by Gray. Nearly all the branchlets are directed upwards, and most of them reach the apex of the corallum, giving a subcorymbose growth. The axis throughout is very slender and brittle. The spines are short, triangular, and compressed, with the apex at right angles to the axis. They are apparently not arranged in regular spirals. Six longitudinal rows are visible from one aspect, the individual members of which are very far apart. Length of spine = $\frac{1}{2}$ diameter of axis; they are separated by an interval equal to three or four times their length (Pl. XI. fig. 2). The members of two adjoining rows are subopposite, recalling the arrangement in *Antipathes mediterranea*, n. sp.

Habitat.—Madeira (Mason), Brit. Mus.

Antipathes? mediterranea, n. sp. (Pl. XI. fig. 9).

Stem (?) straight or subflexuose, round, elongate, about 35 cm. long and 2 mm. in diameter below, very slightly tapering. Branches very distant, 4 to 9 cm. apart, mostly at right angles to the stem, but not all in the same plane. They are usually arranged singly, but

may be occasionally opposite. The main branches have a diameter almost equal to that of the stem at their respective points of origin, and may be 10 cm. long. They usually bear one to four branchlets at right angles, scarcely any two of which extend in the same plane. Some are directed downwards, others horizontally, and others again take a subvertical direction. In another portion of a stem (?) parallel to the longer one, and fused to it by a transverse branch, the branches sometimes form a marked acute angle with the axis, and in one instance three elongate branchlets arise close together. With these exceptions, two most marked characters of the species are (1) the rectangular mode of branching, and (2) the relatively distant, elongate, and usually simple branchlets frequently directed downwards. The only fusion present in the whole specimen is the one already referred to, by which one stem (?), through the agency of two of its branches, becomes fused to the one forming the greater part of the specimen. The spines are strong, triangular, and much compressed, with the apex more turned upwards in some than in others. No spiral arrangement is noticeable, but the spines are arranged in longitudinal rows, seven or eight of which may be seen from one aspect. The rows in some instances seem to be paired, that is, two spines in adjoining rows are opposite to each other. Pl. XI. fig. 9 represents one full cycle of the arrangement from the upper pair of spines adjoining the middle line to the pair beneath them. The spines have a length corresponding to about half the diameter of the axis, and the members of a row are very distant, usually separated by an interval equal to two and a half to three times their length. The polyps of the type specimen are very badly preserved, so that I have been unable to make a microscopic examination of them. They are evidently rather large and prominent; about three are arranged to a centimetre. The position of this species is uncertain pending an examination of the polyps. The spines are evidently of the *Antipathes* type and are similar in shape to those of *Antipathes arborea*, Dana, as figured by Pourtalès.

Habitat.—Mediterranean (Koch) Brit. Mus.; in 32 to 54 fathoms, on rocks covered with Corallines, Naples Zool. Stat.

Genus *Antipathella*, n. gen.

Antipathes (*pars*), Auctt.
Rhipidipathes (*pars*), M.-Edwards, Coralliaires, t. i. p. 320.

Zooids small, usually somewhat longer in the transverse axis, so that the tentacles are arranged biradially or in two parallel rows of three each. The stomodæum is elongated in the sagittal axis, the mouth usually but not invariably so. Sometimes the upper portion of the stomodæum is everted, in which case the mouth is rounded with a crenate inner margin. The tentacles are usually short and subequal, but those in the sagittal axis may be inserted at a slightly lower level than the others. There are ten mesenteries in the oral prominence, and six below, as in *Antipathes*. The reproductive elements are

contained in a thickened portion of the transverse mesenteries. In *Antipathella subpinnata* the cellular elements of the ectoderm are arranged differently to those in *Antipathes dichotoma*, the clusters of nematocysts, in sections, being usually situated in depressions, instead of in the centre of prominent crenations.

The corallum may be laxly branched with all its subdivisions free, or it may become fan-like, extending chiefly in one plane, in which case the lower portions are always confluent, whilst the upper and terminal ones may be completely fused together or free towards the apex. The spines are usually short, triangular, or conical, but, in *Antipathella subpinnata*, they become elongate and slender on the stronger branches and branchlets.

Synopsis of Species.

A. Corallum laxly branched, pinnules usually simple, with or without fusion of parts.
- 1. Pinnules short, distant, free, not all in one plane; spines triangular at first, becoming conical and ultimately needle-like, ... *subpinnata* (E. and S.).
- 2. Corallum laxly branched, pinnules on all sides, elongate, very slender and free; spines triangular, rather numerous, not in a spiral, . . . *strigosa*, n. sp.
- 3. Corallum laxly branched, branches with four irregular rows of short slender pinnules, which are rather distant; spines strong and distant, arranged in unequal sinistrorse spirals, ... *intermedia*, n. sp.
- 4. Corallum branched, with slender paniculate branches, presenting frequent fusions and approaching the characters of section B of this genus; branchlets not all in a plane; spines conical, unequal, disposed in irregular sinistrorse spirals, ... *boscii* (Lamx.).

B. Corallum extending chiefly in one plane; branches confluent, paniculate.

a. Terminal fronds free.
- 1. Whole corallum small and very delicate; spines close-set, short, triangular, compressed, ... *tristis* (Duch.).
- 2. Terminal fronds delicate; spines conical, short, not in a spiral, . . *gracilis* (Gray).
- 3. Terminal fronds delicate; spines conical, short, arranged in open sinistrorse spirals, ... *atlantica* (Gray).
- 4. Terminal fronds strong, tapering; spines short, triangular (?), arranged in verticils, ... *paniculata* (Duch. and Mich.).

β. Terminal fronds fused together.
- 5. Fronds elongate and narrow; spines conical, pointed, arranged in spirals, *minor*, n. sp.
- 6. Fronds broader, but of same type as in sp. 5; spines elongate, conical, not in distinct spirals, ... *speciosa*, n. sp.
- 7. Fronds very broad, delicate; branchlets straight, but otherwise similar to those of sp. 8; spines very numerous and irregular on the pinnules, very thick with a blunt apex, ... *assimilis*, n. sp.
- 8. Fronds broad, delicate, reticulum close, ultimate pinnules setose; spines more elongate, slender, with a sharp apex, ... *reticulata* (Esp.).

C. Corallum flattened, but with pinnules not in a plane.
- 1. Corallum dense and irregular, the strong portions forming a coarse reticulum; pinnules very slender, simple, pinnate, or bipinnate, radiating in all directions; spines short, triangular, . . . *contorta*, n. sp.

Antipathella subpinnata (E. and S.), *non* Gray (Pl. XII. fig. 15; Pl. XIII. figs. 3–8, 10; Pl. XV. figs. 2, 6).

Antipathes subpinnata, Ellis and Solander, Zoophytes, p. 101, pl. xix. figs. 9 and 10; Lamouroux, Polyp. flex., p. 379; Expos. méthod., p. 32, pl. xix. figs. 9 and 10; Blainville, Manuel d'Actinol., p. 511; Dana, Zooph., p. 579; Milne-Edwards, Coralliaires, t. i. p. 318; Lacaze Duthiers, Ann. Sci. Nat. (Zool.), sér. 5, t. iv. pp. 17–48, pls. 1–4.

"*Antipathes* ramosa, pinnata, hispida; pinnulis setaceis alternis, pinnulis aliis (sed raris) transverse exeuntibus" (E. and S., *op. cit.*, p. 101).

The stem and primary branches are strong. The smaller branches are arranged irregularly, and bear a number of simple, subequal, moderately distant pinnules, not over 4 to 5 cm. long, most of which are lateral and subalternate, but a few arise at irregular intervals from the anterior or antero-lateral surface. The polyps are small, rather crowded on the pinnules, but very distant on the main trunks.

I am indebted to Dr. Dohrn, of the Naples Zoological Station, for a portion of a specimen of this species in which the polyps are beautifully preserved. This specimen undoubtedly agrees with Lacaze Duthiers' description and figures of the spines, &c., and is probably the same form as that described by Ellis and Solander, though it differs in one or two points from their description and figures.

My specimen consists of the upper portion of a stem, 24 cm. long and 1·5 mm. in diameter at the base. The stem bears branches and branchlets laterally on both sides, but those on the right are more numerous and important. The main branches (in this, the upper part of the corallum) are 8 to 10 cm. long and from 2 to 4 cm. apart, with a few simple or branched pinnules between them. The larger branches are bipinnate, but the arrangement and size of the pinnules is most irregular. One of the larger branches has three branchlets, which are given off from the lower portion of the branch, at points not situated on the lateral margin, and not all in the same plane. These are 4 to 5·5 cm. long, and bear a number of simple pinnules 1 to 2 cm. long. These are arranged quite irregularly, and there may be four or five on one side and only one on the other. In the upper and more tapering portion of the branch, a number of simple pinnules from 1 to 2 cm. long are arranged subalternately, about nine to 4 cm.; these are more nearly lateral in origin. In other portions a few of the pinnules and pinnate branchlets are arranged in a plane almost at right angles to that of the majority.

In the upper portion of the specimen the stem bears pinnules from 2 to 6 cm. long, arranged quite irregularly, one here and there passing out in a plane almost at right angles to the others. The larger ones, which may be considered branchlets, are laxly and irregularly pinnate. The pinnules are here about 0·5 cm. apart and vary very much in length; most are lateral, but, occasionally, one is directed obliquely in another plane. The shorter pinnules are all simple, as indeed are many of those of medium length, whilst

others bear one or two lateral secondary pinnules, indicating a transition to the bipinnate type.

Two or three of the branches in the lower part of the specimen have been broken near the tip, the lost portion being represented by a new and more slender growth from the point of fracture.

The polyps and cœnenchyma are well preserved all over the specimen. Those polyps situated on the stem, particularly in the lower portion, appear to have undergone considerable degeneration and are altogether smaller and less prominent than those on the branchlets and pinnules. They are arranged somewhat irregularly, evidently not in a single longitudinal row, but apparently all are confined to the anterior and lateral surfaces.

The polyps on the pinnules and branchlets are all situated on the anterior surface, forming a regular longitudinal series. On one simple pinnule, 4 cm. in length, there are thirty polyps, all similar in size and equidistant, with the exception of two at the base which are rather smaller and more isolated. In other portions of the colony, particularly near the apex, the zooids are unequal in size, owing to the fact that by a process of budding new zooids are added at various points along a branchlet. In this respect there is an approach to the arrangement of zooids in *Leiopathes*, but the irregularity in size is never so well marked as in that genus, and the irregularity is here confined to more limited areas. In zooids preserved with the mouth open, the aperture has a distinct crenate outline and there is a partial eversion of the stomodæum, each fold of which is limited by two mesenteries. In such cases (Pl. XIII. fig. 4) the mouth has not the slit-like lumen corresponding to that of the middle portion of the stomodæum, but the aperture is wide and rounded, with a crenate margin. The zooids are irregular in shape, but in a typical case there is always a pronounced elongation in the transverse axis. The zooids on the thicker branches are usually smaller than the others, and have a rounded outline, and in certain cases young zooids have a similar contour, due possibly to the limited areas in which they are at first formed. With these exceptions the zooids invariably show an elongation in the direction of a branch, which causes the tentacles to be arranged in two rows of three each. There is no marked difference in size between the tentacles, all are (in spirit preparations) thick and subcylindrical, with a blunt apex. Lacaze Duthiers, who has studied living specimens, states that the tentacles are never elongate as in many other forms, *Parantipathes larix* for example. In expanded polyps the diameter across the tentacles never exceed $2\frac{1}{2}$ diameters of the pinnule on which they are situated. His figures of the polyps in this species (**45**, pl. i. figs. 3 and 4) represent the rounded type which I have observed on the stronger branches. The latter figure shows a number of polyps contracted, so that the tentacles are pressed down close over the mouth—a condition approaching that which occurs in those Actiniaria having a well-developed sphincter muscle. I have not observed such a contraction in specimens of this or of any other member of the Anti-

pathidæ which has come under my notice. The whole muscular system is apparently rudimentary, and, so far as I know, there is no sphincter muscle present in Antipathidæ which could cause such an appearance. Indeed, the following quotation from Lacaze Duthiers shows that the contraction is general, and not brought about by a special aggregation of muscular fibres. He says: "Leur tissu se contracte, ... et tout le Polype forme un mamelon froncé à son sommet, ... mais sans jamais masquer absolument la bouche et les tentacles" (p. 22).

The spines are short and triangular near the apex of a pinnule, but gradually become more elongate and cylindrical on passing further away from it. Lacaze Duthiers gives a very good figure of the triangular form (45, pl. iv. fig. 18).

The subcylindrical form of spine approaches the *Aphanipathes* type. The spines are relatively long and slender, having a length greater than the diameter of the axis. The spines ultimately become needle-like, with a very slight taper and a sharp point. They are arranged in longitudinal rows, five of which may be counted from one aspect on moderately slender branchlets. The members of a row are about one length apart, and a subspiral arrangement from left to right is often noticeable. The spines are all bent sharply upwards at an acute angle with the axis, and some are distinctly incurved, others bifid. In this species the spines appear to increase in length on the older portions of the corallum, and the earliest (triangular) form passes through a conical phase before reaching the subcylindrical one just described (Pl. XII. fig. 15).

Habitat.—Mediterranean (Ellis, Lacaze Duthiers); in 135 fathoms, Naples Zool. Stat.

Antipathella? strigosa, n. sp. (Pl. XII. fig. 11).

Stem straight, erect, distinctly tapering, 15 cm. long. Branches few, irregularly placed, 3 to 6 cm. long, usually bent upwards subvertically. The stem and branches are clothed with a number of spirally arranged, distant, hair-like pinnules 1 to 5 cm. in length, the lower ones long and bent upwards, those on the upper part of the stem spreading; all are simple. Spines triangular, flattened, the apex standing out almost at right angles to the axis; they have a length about equal to two-thirds the diameter of a pinnule. A spiral arrangement is not apparent, but the spines are distributed in longitudinal rows, five or six of which may be counted from one aspect. The members of a row are relatively far apart, being separated by an interval almost equal to three times the length of a spine. The zooids are small and distant, and are very imperfectly preserved. If they agree with the characters of *Antipathella*, they are more distant than those of any other species known to me. The species appears closely allied to *Antipathella boscii*, (Lamx.), both in the form of the corallum and in the type of spine. The pinnules are, however, always simple.

Habitat.—New Zealand (purchased at the Colonial Exhibition in London, 1886), Brit. Mus.

Antipathella? boscii (Lamx.) (Pl. XII. fig. 29).

Antipathes Boscii, Lamouroux, Polyp. flex., p. 375, pl. xiv. fig. 5; Encycl. Méthod., t. iv. p. 69; Verrill, Mem. Bost. Soc. Nat. Hist., vol. vi. p. 36.

Lamouroux gives a very imperfect description of this species:—"Tige flexueuse, rameuse; rameaux divergents, extremités setacées; couleur brun foncé; grandeur environ un décimetre." Lamouroux's figure shows a species unlike any form which I have seen figured elsewhere. The branches are lax and spreading, and the cœnenchyma appears collected in large masses between the forks of branches at various points.

Verrill appears to be the only other authority who has given us an account of this form, but it is uncertain whether he has described the same species. I append his description at length:—"Corallum finely and densely branched from very near the base, forming an irregular subflabelliform matted frond. Branches slender, numerously divided in an irregularly dichotomous or subpinnate manner, frequently coalescent, especially near the base, the reticulations very irregular. Branchlets slender, setiform, the terminal ones from $\frac{1}{4}$ to 1 inch in length. Surface of the branches and branchlets thickly covered by small acute spines projecting nearly at right angles; between the spines, minutely scabrous. Colour black, branchlets translucent, dark amber coloured. Cœnenchyma not observed. Height 10 inches, breadth 14 inches. The specimen is in the collection of the Museum of Comparative Zoölogy at Harvard College, and was obtained by Louis Agassiz near Charleston, S.C."

The figure which I am enabled to give of the arrangement of the spines in this species (Pl. XII. fig. 27) is taken from a small specimen of Verrill's form in the Copenhagen Zoological Museum, received through the Museum of Comparative Zoology at Harvard College.

Habitat.—S. Carolina, Bosc (Lamouroux); off Charleston (Verrill).

Antipathella? intermedia, n. sp. (Pl. XII. fig. 2).

Corallum laxly and irregularly branched, the stronger branches 3·5 to 7·5 cm. apart. The stem and branches all bear pinnules, which are imperfectly arranged in four different planes; two are lateral and pass out subhorizontally, but are somewhat arched and directed forwards; these are the most abundant. The other two series arise from very near the anterior surface of the axis, and pass off subvertically, but in their upper portions have an antero-lateral inclination. The pinnules are 0·8 to 1·4 mm. apart, irregularly disposed, the lateral ones in a subalternate manner, the others at greater and more irregular intervals. The whole of the pinnules are filiform, usually simple, though one here and there may bear a short secondary pinnule nearly at right angles. At irregular intervals a pinnule increases in size, and practically becomes a branchlet,

bearing lateral and subvertical pinnules in the usual way, their size depending on the size of the branchlet. The pinnules vary from 1·3 to 3·8 cm. in length, but most come nearer the shorter dimension. It is usually (always?) certain of the lateral pinnules which develop into smaller branchlets, and these may be 1·2 to 2·5 cm. apart. The four series of pinnules are often tilted obliquely to one side.

The arrangement of the pinnules in four series brings this form near to *Aphanipathes alata*, but the two are really very different. In this form the branches, branchlets, and pinnules are all slender, and the pinnules are relatively far apart, the smaller lateral branchlets breaking the lax plumose effect which might otherwise be obtained. In *Aphanipathes alata* the lateral pinnules are closely set like the pinnules of a feather, and the whole four series are much more distinct. The two forms differ also in the arrangement of the spines. Here they are relatively large, subconical, and distant, being arranged in irregular open and steep sinistrorse spirals. They are also arranged in longitudinal rows, four of which may be counted from one aspect of a pinnule. The members of a row are from three to four lengths apart (Pl. XII. fig. 2). This species seems more closely related to *Parantipathes hirta* (Gray), but is much more lax in its growth, and the pinnules are longer and more definitely arranged in rows. Its precise position cannot be decided until the polyps have been studied.

Habitat.—Japan (Anderson), Brit. Mus.

Antipathella ? tristis (Duch.).

Rhipidipathes tristis, Duchassaing, Rev. d. Zooph. et d. Spongiaires d. Antilles, Paris, 1870, pp. 23, 24.
Antipathes tristis, Pourtalès, Bull. Mus. Comp. Zoöl., vol. vi. p. 115, pl. iii. fig. 10.

"Humilis, delicatula, 3 pollicaris, flabellatim expansa; ramis tenuibus, capillaribus, tenuissime (oculo armato) hirsutis, reticulatim anastomosantibus, nec nodoso-strangulatis" (Duchassaing, *op. cit.*, p. 23).

Pourtalès obtained several specimens of this delicate species from 3 to 4 inches high. He remarks that the branches are very slender, and anastomoses not plentiful; they are more properly defined as adherences. The spines are sharp, triangular, and arranged in irregular dextrorse (?) spirals (*cf.* Pourt., **71**, pl. iii. fig. 10). Polyps small, with short digitiform tentacles and moderately prominent mouth; the two lower tentacles are sometimes laid around the mouth, as in *Stichopathes pourtalesi*.

Habitat.—Guadeloupe, 200 feet (Duchassaing). Ranges from 45 to 226 fathoms in eight stations off Santa Cruz, Montserrat, Martinique, St. Lucia, and Barbadoes (Pourtalès).

Antipathella? atlantica (Gray), mihi. (Pl. XII. fig. 5).

Antipathes atlantica, Gray, Proc. Zool. Soc. Lond., 1857, p. 291.
Antipathes reticulata, Gray (*non* Esper), Proc. Zool. Soc. Lond., 1857, p. 291.

"Coral shrub-like, branched; branches fan-like, irregularly pinnate; branchlets elongate, with distant subulate pinnæ, the larger ones sometimes pinnated, the branches and branchlets often anastomosing" (Gray, *loc. cit.*).

I find no specimen in the British Museum Collection which bears the name *Antipathes atlantica*, but there are a number of West Indian specimens which should include the type of this species. All bear the locality and register number in Gray's handwriting; one bears the name *Antipathes reticulata*, also in his handwriting, the others are either unnamed or have been since queried by S. O. Ridley. There appears nothing in Gray's definition of the two species to enable one to distinguish one from the other, excepting that *Antipathes reticulata* is described as more slender.

The specimen, labelled *Antipathes reticulata* by Gray, is small (30 by 25 cm.) and very delicate throughout. The base of the main stem is about 2 mm. in diameter. It, however, bears no resemblance to Esper's figure of *Antipathes reticulata* (Pall.), and lacks the definite reticulum, the short setose pinnules, and has not nearly such strong spines. A much stronger specimen which I at first thought to be distinct, and probably Gray's type of *Antipathes atlantica*, proves to be merely a larger specimen of the same species having stouter branches; the fusions are not so numerous amongst the apical branches, which thus become more free and arranged in fan-like groups. The spines have precisely the same arrangement as in Gray's type of *Antipathes reticulata*, but are more numerous on account of the greater strength of the axis. As this species differs from the true *Antipathella reticulata* (Esper), and as it is possible that Gray, like myself, may have been misled by a cursory examination of the larger specimen, I propose to retain the specific name *atlantica* for the species now described. It is synonymous with *Antipathes reticulata* (Gray), and may probably also be the species which Gray intended as his *Antipathes atlantica*.

This species has a similar habit to Gray's *Antipathes gracilis*, but is much more delicate. One specimen is 24 cm. high and 34 cm. broad, another 36 cm. high and only 28 cm. broad; all have a dilated base for attachment. The stem is slender, from 2 to 3 mm. in diameter, and the basal branches are fused together by transverse bridges. The secondary branches are arranged at irregular intervals and are nearly always very slender; they are subalternate, and from 6 to 12 cm. long. The smaller branches bear lateral, distant, pinnate, bipinnate or, in some cases, tripinnate branchlets, usually more numerous on one side of the branch than on the other, and all extending almost in one plane. Branchlets (pinnules) up to 1 or 1·5 cm. in length usually remain simple, the others being all more or less subdivided. Fusions are frequent throughout a colony, but

are more numerous in some specimens than in others. No regular reticulum is formed, and the distal portion of each paniculate branch at the apex of the corallum is free from its neighbour. This is the most delicate species which has come under my notice, and differs from the similarly delicate *Antipathella? tristis* (Duch.) both in the shape and arrangement of the spines. The whole corallum is usually flat, but in one specimen a laxly-branched portion extends in a plane behind the main-mass, and almost parallel with it. In some of the specimens, although dry, the polyps are shown as very small bead-like elevations on the branchlets; there are usually 9 or 10 to a centimetre. The spines are short and conical with a slender apex (Pl. XII. fig. 5). They are arranged in steep sinistrorse spirals, which are rather far apart. Five longitudinal rows may be counted from one aspect of a branchlet, the members of a row being from four to five lengths apart.

Habitat.—West Indies (Scrivener), Brit. Mus.

Antipathella? gracilis (Gray) (Pl. XI. fig. 8).

Antipathes gracilis, Gray, Ann. and Mag. Nat. Hist., ser. 3, vol. vi., 1860, p. 311; (non *Antipathes* (*Cirrhipathes*) *gracilis*, Gray).

Gray's description is as follows :—

"Coral rather fan-like, expanded, very slender, repeatedly forked. Branches very slender, elongate, subsimple, tapering; stem and branches covered with very close rather elongate spinules. Hab. Madeira.

"The coral is six inches high, rather fan-like, in a single plane; stem slender, about as thick as a thick bristle, subalternately branched, with the rows of branches on the outer side, giving them the appearance of being forked; the branches and branchlets elongate, very slender and subsimple and gradually tapering till they are quite hair-like."

I am at a loss to understand Gray's description, as the only specimen in the British Museum Collection which I could find, bearing the name *Antipathes gracilis* in his own handwriting is 56 cm. high, and labelled from the West Indies. This specimen is evidently related to other flabellate forms now included in the genus *Antipathella*. The base consists of several stems fused together, which give rise to a series of branches not all in the same plane, but presenting frequent fusions between neighbouring branches. The upper portion is more spreading, but the larger branches are still strong and frequently fuse with one another. In some portions nearly all the branches come off from one side and are placed at irregular intervals. Nearly all the secondary branches are very slender. Medium branches bear branchlets irregularly, varying in length from 1·5 to 10 cm., usually longer on one side than the other. The smaller branchlets are simple and filiform; the larger ones are again branched irregularly, the ultimate pinnules being very slender, and rarely attaining a length of 1·2 cm. without becoming branched. The spines are similar in size and shape to those of *Antipathella atlantica* (Gray), but are

arranged in dextrorse spirals, which are not nearly so steep as those of that species. Five longitudinal rows are visible from one aspect of a pinnule, the members of a row being two to three lengths apart (Pl. XI. fig. 8). It seems doubtful whether this specimen can be considered to agree with Gray's definition of the species. There appears, however, no doubt that he regarded it as belonging to his *Antipathes gracilis*, and in the absence of the Madeira specimen, it must be regarded as the type. There is apparently no specimen of this species from Madeira in the British Museum.

Habitat.—West Indies (Scrivener), Brit. Mus.; ? Madeira (Gray).

Antipathella? paniculata (Duch. and Mich.).

Arachnopathes paniculata, Duch. and Mich., Mem. Acad. Torino, ser. 2, t. xxiii. p. 142, pl. vii. figs. 1, 2; Duch., Rev. d. Coralliaires, &c., d. Antilles, 1870, p. 23.

"Sp. e basi ramosa, multiores divisa, paniculata, ramis præcipuis teretibus mediocribus; ultimis flabellatim ramosis, ramulis terminalibus setaceis, semi-pollicaribus" (D. and M., p. 142).

This form has a similar habit to *Antipathella atlantica* (Gray), but is more regularly bipinnate in its branchlets, and the whole specimen, judging from Duchassaing and Michelotti's fig. 1, is much stronger, with markedly tapering branches. Each terminal paniculate frond appears to be quite free and not fused with its neighbour. The spines are short, conical, and pointed, and are arranged in subregular verticils around the axis (*cf.* Duch. and Mich., *op. cit.*, pl. vii. fig. 2).

The corallum taken as a whole forms a very lax panicle, and the terminal branches are fan-like. Anastomoses are frequent between the stronger portions of the corallum. The sclerenchyma is black in the stem and branches, but yellowish brown in the branchlets and pinnules. Height about 30 cm. This species may be distinguished from others of the genus by its stronger and more tapering paniculate branchlets and by the fact that the spines are arranged in verticils.

Habitat.—Off Guadeloupe in 33 to 50 fathoms (Duch. and Mich.).

Antipathella minor, n. sp. (Pl. I. figs. 1–3).

Corallum rather delicate, forming a flabellum composed chiefly of elongate narrow fronds, which are imperfectly fused together (Pl. I. figs. 1, 2, 3).

The type specimen is 43 cm. long, and is 14 cm. wide across the broadest portion. The base of the stem is dilated into a rounded disc for attachment. The main stem is 2 mm. thick, sinuose at its base, and tapers quickly, becoming lost about half-way up the colony. It gives off numerous branches (1 to 1·2 mm. in diameter), arranged irregularly, some of which remain comparatively short and often fuse with others. From the upper

surface of the primary branches a number of elongate branches arise which are directed upwards, taking an almost vertical direction. These constitute the most important branches of the corallum, and may be 10 to 18 cm. in length. They usually become considerably thickened some distance above their origin, and bear a further series of branchlets, without definite arrangement, which may be 0·5 to 1·5 cm. apart, and 3 to 4 cm. long. In addition to these, forming the framework so to speak of the colony, the stem, branches, and branchlets, all bear a number of lateral pinnules which are usually alternate, but the arrangement is often irregular. An enormous development of certain of these pinnules gives rise to the secondary branches and branchlets. They are usually from 0·5 to 1 cm. long, and about 0·2 cm. apart, but near the apex of the corallum certain pinnules are much elongated and bipinnate, or more rarely tripinnate. Fusions are frequent in all parts of the corallum.

The polyps are small and rounded, showing a tendency to become elongated in the direction of growth, as is usual in this genus. The tentacles are short rounded lobes arranged in a ring around the oral disc, or in the more elongate individuals the tentacles are more nearly arranged in two rows at each end of the long axis of the stomodæum. The mouth is situated in the centre of an elevated and rounded oral disc, as large as one of the tentacles. On the larger branches the polyps are frequently distributed in two alternate rows, one on each side of the median line on the anterior surface. They also extend to the posterior surface, but are not so numerous there nor arranged with such regularity. On the branchlets and pinnules the polyps are arranged in a single row along the anterior aspect of the corallum. The various polyps on a pinnule are closely crowded, particularly in the younger portions of the colony. There are usually about seven to a centimetre on the pinnules.

The spines are short, conical, but somewhat compressed, and are generally bent slightly upwards, and have moderately sharp points. They are arranged in steep spirals from left to right, and also in longitudinal rows. Four rows may be counted from one aspect of a pinnule, the members of a row being about two lengths apart. It will be seen by a reference to Pl. I. fig. 3, that the members of a spiral are placed at regular intervals one above another, so that, of the four series figured, the right hand row is inserted at a point on the axis slightly above that on the left hand. In *Antipathella assimilis* (*cf.* Pl. I. fig. 6) this is not the case. This species is readily distinguished from other members of the genus, on account of the fact that its branches and branchlets form long, narrow, and slender pinnate fronds, rarely more than 2 cm. across the pinnæ. *Antipathella speciosa* comes nearest to it in this respect, but in the species under consideration the whole corallum is relatively long and narrow, the growth is not so regular, and the pinnules of neighbouring branchlets do not appear to be so firmly fused together into a reticulum.

Habitat.—Station 308; January 5, 1876; lat. 50° 8′ 30″ S., long. 74° 41′ 0″ W.; Strait of Magellan; depth, 175 fathoms; bottom, blue mud.

Antipathella ? speciosa, n. sp. (Pl. II. figs. 5–7).

Corallum consisting of several very large flabellate fronds springing from a strong basal framework. The main divisions of each frond are chiefly in one plane, but in dry specimens the surface may be undulating, and the margins of the smaller fronds are gracefully incurved. A large number of short pinnate branchlets project subvertically from the anterior surface of the corallum, and are not included in the general reticulum.

The largest fan-like frond measures 1 m. in height; it is only about 12 cm. broad at the base, but rapidly spreads out so as to be over 1 m. broad near the apex. The lower portion consists of a number of radiating branches, 3 to 6 mm. in diameter, which have a very irregular course. These are connected together by bridges of sclerenchyma at frequent intervals, forming an irregular reticulum, the meshes of which are filled in with slender pinnate branches. Branches 3 to 4 mm. in diameter reach halfway up the colony, but the lower ones often taper away to smaller branches after a course of 18 to 30 cm., and give rise to others which become thickened some distance from their origin, and so continue the stronger portions of the axis to a greater height. About 20 cm. from the apex of the corallum the branches are 1 to 2 mm. in diameter, being usually much compressed laterally. These give rise to a number of branchlets at irregular intervals, which are 6 to 10 cm. long and mostly take a subvertical course. The derivatives of five of these branchlets may occupy 14 or 15 cm. in the breadth of the corallum. Each branchlet bears a large number of subalternate slender pinnules, eight or nine of which may be distributed to each centimetre in length. Most are about 1 cm. long and simple, and though chiefly lateral are certainly not always so. At intervals of 0·5 to 1·5 cm. a pinnule becomes elongated and alternately pinnate, and may reach a length of 4 cm. without showing any considerable increase in thickness. The pinnules of adjoining branchlets become fused with one another quite close to the apex of the corallum (Pl. II. figs. 5, 6).

The spines are similar in shape to those of *Antipathella minor*, but are larger and more pointed. A spiral arrangement is not marked, but the spines are arranged in regular longitudinal rows, five of which may be counted from one aspect of a pinnule. The members of a row are from two to two and a half lengths apart (Pl. II. fig. 7).

The specimen is dry and the whole corallum is covered with a thin brown semi-transparent film soluble in caustic potash, the presence of which has made it impossible to give a good figure of the specimen. Apparently, no polyps remain even as small rounded prominences along the pinnules, such as may be observed frequently in dry specimens. It is difficult to understand how such a continuous brown film has been produced. Nothing of a similar nature has come under my notice in other specimens. So far as I can ascertain the specimen when obtained was completely covered with a

viscous substance, probably secreted by some other animal, and this in drying may have produced the appearance referred to.

The portion of the specimen figured is 80 cm. long, and bears a strong short basal framework to which several large fan-like fronds have been attached.

Habitat.—Station 308; January 5, 1876; lat. 50° 8′ 30″ S., long. 74° 41′ 0″ W.; Strait of Magellan; depth, 175 fathoms; bottom, blue mud.

Antipathella reticulata, (Esper) *non* Gray (Pl. XII. fig. 3).

Antipathes reticulata, Esper, Pflanzenth. Fortsetz., pt. i. p. 183, pl. Antip. 11; Pourtalès, Bull. Mus. Comp. Zoöl., 1880, pl. iii. fig. 22.
Rhipidipathes reticulata, Milne-Edwards, Coralliaires, vol. i. p. 321.

"A. explanata ramis inordinato adscendentibus, ramulis clathratis, scaberrimis" (Esper, *loc cit.*).

The type in the Erlangen University Museum is not a complete specimen, but Esper thinks it may have been about 30 cm. in diameter. The whole surface is flattened, and the branches, which are slender and placed irregularly, become fused together into an open lattice work. All the branches are subalternately pinnate bearing straight or somewhat arched pinnules, the smaller ones coming off nearly at right angles, the larger ones often at an acute angle. On the apical and smaller branches the pinnules are usually simple and about 6 to 12 mm. long and comparatively regular in position, about eight to a centimetre. Some of the longer ones bear one or more very short secondary pinnules coming off at right angles and usually on one side only.

In an older portion of the colony the pinnules become 2·5 to 4 cm. long and much stronger, bearing secondary pinnules at right angles and often on both sides, similar in all respects to those in the upper portion of the specimen, but often longer (2 to 6 mm.).

The whole of the pinnules, both primary and secondary, form a lacework between the branches, and anastomoses are frequent in all parts of the colony. Esper describes the spines as close-set, obtuse, and stiff, sometimes club-shaped, and sometimes pointed. Judging from his figures they are very strong and large for such a delicate species. This species does not appear to have been described by subsequent investigators. Lamarck, Lamouroux, and Dana repeat Esper's definition. If Esper's plate xi. is to be relied on, the species is certainly unlike any with which I am acquainted. The specimen which Gray (Proc. Zool. Soc. Lond., 1857) refers to this species is really widely different and more closely allied to *Antipathella gracilis* (Gray). It has none of the short stiff secondary pinnules so characteristic of this form, and also differs considerably in the size and arrangement of the spines.

There are two specimens in the Copenhagen University Museum which appear to be

referable to this species. One, which was purchased by Professor Steenstrup at Cette and is probably from the East Indies, bears four fine specimens of the rare *Rhizochilus antipathum*, Stp. This specimen is 26 cm. high and 41 cm. broad. The stem is strong and the branches are distinctly stronger than the branchlets; the latter only become reduced to the thickness of the pinnules at the extreme apex of the corallum. Fusions are numerous and extend quite to the apex of the specimen. The branches and their derivatives form flat leaf-like fronds, not all in the same plane, but the subdivisions of each are chiefly in one plane. Part of the reticulum forms a median vertical plate at right angles to the main growth; I have observed a similar condition in *Tylopathes? flabellum* (Pall.). The other specimen, received through the Museum of Comparative Zoology at Harvard College from Manila, is smaller and does not show such a contrast between the thickness of the branches and branchlets.

The spines are conical with a sharp apex, and are placed at right angles to the axis; they are arranged in regular sinistrorse spirals, excepting near the apex of a pinnule. Six longitudinal rows may be counted from one aspect, the members of a row being about two and a half lengths apart. Near the apex of a pinnule they are somewhat triangular, but never crowded and thickened as in *Antipathella assimilis*. On the older portions they are subcylindrical and more elongate than is shown in Pl. XII. fig. 3.

Habitat.—East Indies? (Esper); Manila (Mus. Comp. Zool. Harvard Coll.).

Antipathella assimilis, n. sp. (Pl. I. figs. 4–7).

Corallum forming a flabellate reticulum similar to that of *Antipathella reticulata* (Esp.), but the lateral branchlets are longer, not arched, and the reticulum is closer. The spines are at first crowded and very irregular in shape; later they have a blunt apex and are arranged in dextrorse spirals (Pl. I. figs. 4, 5, 6, 7).

The specimen consists of the apical portion of a branch fused with the derivatives of other branches. This specimen is 16 cm. in length and 12 cm. broad. The main branch is 16 cm. long, and gives off numerous lateral alternate branches, about five to a centimetre. Some of these are 6 to 7 cm. long, but most are considerably shorter. A number of them are slender and simple, not over 1 cm. long, and are, in all respects, similar to the ultimate pinnules. Most, however, bear alternate pinnules (3–5 to 1 cm.), the longer of these being again alternately pinnate. The whole specimen extends chiefly in one plane, but a few of the pinnules arise from the antero-lateral margin of the branchlets and thus destroy the uniformity. Some of these are pinnate and have then the appearance of a small frond inserted obliquely into the general mass. The sclerenchyma is dark reddish brown. The pinnules of adjoining branchlets overlap one another and become fused together into a network, and the branchlets derived from one branch, taking a subvertical course, become confluent with others which extend subhorizontally and are derived from

another part. The zooids are small and crowded; they are not always disposed in a single row on the stronger portions of the corallum, though this is usually the case on the branchlets and pinnules. Such rows of zooids are not, however, invariably confined to one surface of a branchlet, but may turn gently round the axis. There are usually about seven zooids to 1 cm., but they are more crowded on some parts than on others. The zooids are of the normal type in this genus, and show a slight elongation in the transverse axis. The peristome is elevated into a rounded knob, between the sagittal tentacles, on the surface of which the mouth opens. The tentacles are short, subcylindrical, and relatively thick.

The spines are very irregular in shape and size. On the slender pinnules they form dense and irregular masses, apparently arranged in no particular order. Each spine is very thick and often shows one or two dilations due to the irregular deposition of one horny layer on the top of another. This condition is followed by a more regular one in which the spines are distinctly arranged in dextrorse spirals, between which a single spine appears to be regularly interposed (Pl. I. fig. 6). In such cases the spines are more regular in size and shape; they are somewhat hooked upwards, and always have a blunt apex. The spirals are not so steep as those of *Antipathella minor*. Five longitudinal rows may be counted from one aspect, four of which are included in the spiral arrangement. The members of a row are about two lengths apart. On the stronger portions of the corallum the spines become more slender and pointed.

I was at first inclined to regard this specimen as identical with *Antipathella reticulata* (Esp.), an East Indian species, but an examination of the Copenhagen specimens of that species has shown the two forms to differ considerably, both in the form and in the arrangement of the spines.

Habitat.—Station 308; January 5, 1876; lat. 50° 8′ 30″ S., long. 74° 41′ 0″ W.; Strait of Magellan; depth, 175 fathoms; bottom, blue mud.

Antipathella contorta, n. sp. (Pl. I. figs. 8–11).

A fine spirit specimen of this species from the Strait of Magellan measures 60 cm. in length and 45 cm. across the broadest part. Two or three large pieces are preserved, which may have all formed one colony. The base is not preserved, but the strongest part of the stem (?) consists of two parts fused together, and has an oval section measuring 1·6 × 0·8 cm. Another single stem or main branch is nearly round, and has a diameter of 1 cm. Each stem or main branch gives rise to three or four strong branches, 5 to 8 mm. in diameter, which extend chiefly in one plane. Numerous more slender portions pass across from one branch to another, forming an open and irregular reticulum. The strong branches are long and irregular in their course (40 to 50 cm.), and have a section which in some parts is round, in others much flattened. These give rise to a number of smaller

branches 1·5 to 2 mm. in diameter, and from 10 to 15 cm. long. These are from 3 to 6 cm. apart, and form a very wide angle with the stronger branches in the lower portion of the corallum, but above they are closer together, and not so spreading. One of these branches with the mass of branchlets and pinnules into which it becomes divided is represented in Pl. I. fig. 8.

Such a branch becomes divided into a large number of close-set subalternate branchlets, from 2 to 4 cm. long, which extend chiefly in one plane. There are usually about six of these to a centimetre. The branches and branchlets are further clothed with innumerable short slender pinnules, which are not confined to one plane, but pass out in all directions. These vary from 0·3 to 1·5 cm. in length. Those up to about 0·4 cm. are usually simple, but the others bear secondary pinnules about 0·5 cm. long, which have a subspiral arrangement. A pinnule of 1 cm. in length may bear five to twelve secondary pinnules, one or two of which may be again subdivided. The pinnules springing from the lateral surfaces of a branchlet usually become fused with those derived from adjoining branchlets, but those on the anterior or posterior surfaces usually remain free. The pinnules on the anterior surface of a branch, &c., are usually so crowded as to completely hide the stronger portions under them. In the lower part of the corallum the smaller branches are most irregular, and give off a number of short stiff branchlets, by means of which a most irregular reticulum is formed (Pl. I. fig. 10). In such portions the pinnules are even more slender than those above. The longer ones are pinnate or bipinnate, and form a confused mass of delicate hair-like twigs, which pass off in all directions and fill up the meshes of the coarser reticulum. Such portions recall Morison's figure of his zoophyte, No. 18 (6, pl. x.), a species which Pallas regarded as belonging to his *Antipathes clathrata*. I have not seen a specimen which conforms to the definition of *Antipathes clathrata* given by Pallas, and the species does not appear to have been studied by recent observers. From the scanty information available, I am, however, inclined to think it more nearly related to *Arachnopathes ericoides* (Pallas), and *Arachnopathes aculeata*, n. sp., than to the species under consideration.

In *Antipathella contorta* the corallum is rendered still more complex from the fact that on a number of the branches and stronger branchlets, many of the pinnules become modified into a hollow cylindrical reticulum, which is inhabited by a parasitic Annelid. The tubular reticulum has a structure similar to that of *Tylopathes crispa*, n. sp. (*cf.* Pl. III. fig. 2), but the meshes are closer and the arrangement more irregular.

The polyps are very similar to those of *Antipathella minor*, but are frequently so crowded that the outline of each is not well defined. The usual arrangement is considerably closer than that shown in Pl. I. fig. 9. The polyps on the reticulum, which serves as shelter for an Annelid, are (in spirit) smaller and paler than the others. The tentacles often project as small rounded processes, no larger than the median prominence of the peristome on which the mouth opens.

The spines are small, numerous, and triangular, with a sharp apex. The base is broad, often equal to the length of the spine. The upper side of the triangle is usually nearly straight, and extends in a plane nearly at right angles to the axis of the branchlet. The spines are apparently not arranged spirally, but in a typical portion are disposed in longitudinal rows, five of which may be counted from one aspect. Two of these, situated on the margins, have the spines at the same level; two other rows, the spines of which are again opposite, are arranged on each side of the middle line, whilst the fifth row passes down the centre of the axis in the aspect figured (Pl. I. fig. 11). The members of a row are two and a half to three lengths apart.

Habitat.—Station 308; January 5, 1876; lat. 50° 8′ 30″ S., long. 74° 41′ 0″ W., Strait of Magellan; depth, 175 fathoms; bottom, blue mud.

Genus *Aphanipathes*, n. gen.

Antipathes (*pars*), Auctt.

Corallum shrub-like with the branches free, or fan-like and reticulate. Spines usually elongate, equal, or longer in the polyp areas, smooth or papillose.

Polyps small and inconspicuous, often obscured by the elongate spines, which project through the peristome of many species, in spirit specimens. They have a more or less oval outline, the greatest diameter corresponding with the skeletal axis. The polyps are separated from one another by a depression of variable extent, through which the inter-zooidal communication is established by means of an axial stolon-like prolongation of their cœlentera, as in most other Antipathidæ. The tentacles are usually very short, and project little beyond the surface of the peristome. They may, in spirit specimens, be reduced to mammiform elevations of the peristome, often difficult to make out amongst the projecting apices of the spines. In this genus the tentacles all arise from the peristome, and have a radiate or biradiate arrangement. Spines project through the soft tissues in numbers varying with the species. They often are pressed in amongst the mesenterial filaments, and sometimes project into the stomodæum. In such cases each spine is covered with a mesoglœal sheath clothed with entoderm, within which is the axis epithelium. The mouth is usually somewhat elongated in the sagittal axis, but the elongation is rarely very pronounced. There are ten mesenteries, arranged as in *Antipathes*. Probably, on account of the compressed form of the polyp, the secondary mesenteries are in this genus relatively more important, and reach nearly to the base of the cœlenteron.

In addition to the species which I have been enabled to study, a number of those described by Pourtalès, having a type of polyp which he terms "sessile," have been included in the genus. The structure of the zooids of these forms is, however, not known,

so that their true position is still uncertain. A number of others, of which the polyps are not known, are also temporarily included, solely from a comparison of their skeletal characters.

Synopsis of Species.

Section I.—Corallum shrub-like, not in one plane, without any regular fusion of parts, but occasionally a few of the branches may be adherent.

A. Spines subequal, not longer in the neighbourhood of the polyps.

a. Branches spreading, virgate, without slender pinnules.

1. Corallum laxly and irregularly branched, like a spray of broom; branchlets relatively thick; spines very long and closely set, . . *sarothamnoides*, n. sp.
2. Corallum irregularly branched, with long, slender, drooping pinnules; spines thorn-like in irregular longitudinal rows, . . . *salix* (Pourt.).
3. Corallum laxly flabellate, flattened; branchlets long and slender; pinnules all on one side; spines of two very distinct sizes, the smaller regularly distributed between the larger, ... *fruticosa* (Gray).
4. Corallum allied to that of *Aphanipathes fruticosa*, in mode of branching; spines arranged in verticils, and covered with sharp spinose processes, . *verticillata*, n. sp.
5. Branchlets long and straight, chiefly in one plane and collected into fan-like groups, simple, or bearing two or three secondary branchlets; spines rough, with a blunt apex, ... *pedata* (Gray).

β. Branches bearing two or more rows of slender pinnules.

6. Stem branched; branchlets bearing two lateral alternate rows of closely-set pinnules, certain of which become elongate and pinnate; spines elongate, broad and flattened, arranged in close dextrorse spirals, . . *pennacea* (Pall.).
7. Stem simple, short, bearing relatively long, alternate, simple, closely set pinnules; spines acicular, in irregular longitudinal rows, . . *eupteridea* (Lamx.).
8. Stem branched, branches collected into groups, bearing four rows of pinnules, two lateral and relatively close, others from antero-lateral margins, irregular and more distant; spines rough, arranged in irregular dextrorse spirals, ... *alata*, n. sp.
9. Stem branched, branches bearing slender pinnules arranged spirally; spines simple, tapering to a slender point, arranged in steep irregular dextrorse spirals, ... *wollastoni* (Gray, MS.).
10. Stem simple; branchlets in five equidistant, subhorizontal rows, lower ones bearing one or two simple or forked processes near the base; spines broad and much flattened, ... *barbadensis*, n. sp.

B. Spines longer about the polyps, giving an appearance of successive swellings on the axis.

1. Corallum subflabellate; spines exceedingly long and numerous, forming dense moniliform dilations of the axis in the region of each zooid, . *humilis* (Pourt.).
2. Corallum densely flabellate, branches without regular pinnate arrangement; spines rather short, excepting a few in the neighbourhood of each zooid, which are long and slender, ... *thyroides* (Pourt.).
3. Branches regularly pinnate; pinnules lateral, nearly at right angles, short, with spinose processes; longer spines slightly rugose, . . *filix* (Pourt.).

4. Stem simple; pinnules arranged in lax spirals, simple, slender; longer spines slightly rugose (?) . . . . . *abietina* (Pourt.).

Section II.—Corallum fan-like, the main branches in one plane. Branches confluent.

1. Corallum large, extending more in breadth than in height, without any thick branches excepting near the base; spines elongate, conical, covered with numerous short sharp serrations, . . . *cancellata*, n. sp.

Aphanipathes sarothamnoides, n. sp. (Pl. V. figs. 6–9; Pl. XIV. figs. 2, 3).

The mode of branching in this species closely resembles that of a spray of broom. The corallum is about 30 cm. high, but the specimen is not complete. The stem (or main branch ?) is short and tapering, having a diameter of 2 mm. at the base. It gives rise to three or four elongate branches which arise at a narrow acute angle. Each of these gives rise to a large number of branches at acute angles, nearly all of which take a subvertical course. One branch, 15 cm. long, bears five primary branchlets at intervals of 1·5 to 2·5 cm., all of which arise from the same side. The lower ones are 5 to 6 cm. long, simple or bearing a single secondary branchlet at a very narrow acute angle; all taper gradually to a long slender point. The two upper branchlets are longer than the others (9 to 10 cm.); the lower one bears two secondary branchlets about the middle on the outer side, one of which is short. The upper one is forked near the base, and each portion bears two secondary branchlets, in one case on the inner side, in the other on opposite sides; the longest measures 6 cm. In most cases the primary branchlets all spring from the same side of a branch (Pl. V. figs. 6, 7).

The polyps appear as small rounded or oval prominences on the sclerenchyma, and all are confined to one aspect of the corallum. They are usually oval in outline, the interzooidal areas being merely indicated by a contraction of the tissues. About six are distributed to each centimetre. The tentacles are short cylindrical processes, those in the sagittal axis being sometimes rather longer than the others. The mouth is oval or rounded, but sometimes an elongation in the sagittal axis is moderately well marked (Pl. V. fig. 8).

The spines are subcylindrical, with a blunt apex and a broad compressed base extending longitudinally. Each spine bears a number of short blunt processes on its distal half. The spines are not arranged in any very evident spiral manner, but are disposed in longitudinal rows, seven of which are visible from one aspect of a pinnule. The spines are all bent upwards from the base, and the members of a row are rather less than two lengths apart (Pl. V. figs. 9, 9*a*).

This species approaches several others of the genus in its type of branching, but is readily distinguished by the form of spine. The polyps are more prominent than those of *Aphanipathes cancellata*, and the spines are of quite a different type. It is possible that a careful study of the structure of the species at present included in this genus may reveal important differences, but at present the information available appears too limited to justify a further subdivision.

Habitat.—Station 177; August 18, 1874; lat. 16° 45′ S., long. 168° 7′ E.; off Api, New Hebrides; depth, 63 to 130 fathoms; bottom, volcanic sand.

Aphanipathes? salix (Pourt.).

Antipathes salix, Pourtalès, Bull. Mus. Comp. Zoöl., 1880, p. 117, pl. iii. fig. 8.
Antipathes rigida, Pourtalès, *Ibid.*, p. 117, pl. iii. fig. 12.

"Irregularly branching, with long slender pinnules not disposed in any particular order, like a weeping willow. The spines are equal, long triangular, somewhat hooked up, and rather close set; on the large branches they form longitudinal rows which are more or less regular. Polyps very small and inconspicuous, of the sessile type" (Pourtalès, *loc. cit.*).

Pourtalès remarks that this species somewhat resembles *Arachnopathes paniculata*, Duch. and Mich. (non *Antipathes paniculata*, Esper), but is more flexuose, has no coalescent branches, and the spines are not in verticils.

Var. *rigida*, Pourt.

The species which Pourtalès describes under this name can scarcely be considered more than a variety of *Aphanipathes salix*. It differs only in being stiffer, with thicker pinnules and occasional coalescence (fusion ?) of the branches. The polyps are of the same type, and the spines only differ in not being so closely set.

Habitat.—Type, off Guadeloupe in 183 fathoms; var. *rigida*, off Barbadoes in 103 fathoms.

Aphanipathes? fruticosa (Gray) (Pl. XI. fig. 7).

Antipathes fruticosa, Gray, Proc. Zool. Soc. Lond., 1857, p. 291.

The following is Gray's description:—

"Coral shrub-like, very branchy, branchlets linear, elongate, with a few distant elongate branches, sometimes in a single row, coming from the same side of the branchlet, spinules rather far apart."

The type specimens are in the British Museum (Reg. Nos. 46. 8. 3. 130., &c.). The corallum is about 60 cm. high, much and irregularly branched, not in one plane, but the whole mass is somewhat flattened. Both primary and secondary branches are irregularly placed, and bear long rigid filiform branchlets from 3 to 10 cm. in length. These are usually simple, but sometimes bear moderately long secondary branchlets on one side only. The long simple branchlets give this species somewhat the appearance of *Aphanipathes? pedata* (Gray), but they are scattered instead of being collected into small fan-like groups. The spines are of two very distinct sizes. The large ones form elongated cones with a relatively narrow base, and have a length equal to about two-thirds the diameter of a pinnule. They are not arranged spirally, but occur in longitudinal rows, seven or eight of which may be counted from one aspect. The spines in some of the rows are more numerous than those in others; they are from one to two lengths apart, and have an arrangement similar to those of *Antipathes mediterranea*, n. sp. In some cases the large spines extend horizontally, in others they form an acute angle with the axis, but the spines themselves are rarely bent. The interval between the large spines is filled in with irregular longitudinal rows of very short subtriangular spines with a sharp apex.

Habitat.—Stephens Island, New Zealand (Jukes), Brit. Mus.

Aphanipathes? verticillata, n. sp. (Pl. XII. figs. 25, 25*a*).

A branched species with long subsimple branchlets having much the habit of *Aphanipathes fruticosa* (Gray), but the spines are in verticils and each is covered with strong spinous processes.

Height of the corallum 80 cm., spread 70 cm. The base is strong, and the lower branches are 4 to 5 mm. in diameter. The more slender branches bear a number of elongate branchlets which usually all spring from the same side of the branch. These are usually close together, about six in 3 cm., and have a diameter of 1 to 1·5 mm. at the base. They vary in length from 5 to 20 cm. or more. These may be simple, or, in the case of the longer ones, may bear a secondary elongate branchlet 6 to 10 cm. long. Both primary and secondary branchlets may in addition bear a short tertiary branchlet some distance from the apex, from 1 to 2 cm. long. The specimen is dry, but the polyps are preserved on many of the branchlets. They form regular longitudinal series, and there are about six polyps to each centimetre. Whether they present the generic characters of *Aphanipathes* cannot be decided with certainty at present.

The spines are arranged in verticils from one and a half to two lengths apart. Usually seven or eight spines in each verticil may be seen from one aspect. The spines are also disposed in longitudinal rows with considerable regularity. Each spine is about twice as long as broad (at the base), and gradually tapers to a sharp point. It is densely covered

with short, pointed protuberances, which are more acute than those of any other species with which I am acquainted. This is the only described species in which the spines, in addition to being arranged in verticils, are covered with numerous conical protuberances.

The type specimen is in the Zoological Museum of the University of Copenhagen.

Habitat.—Mauritius (Andrea).

Aphanipathes? alata, n. sp. (Pl. XI. figs. 3, 3*a*).

Stem thick, round and erect; branched irregularly, the main branches crowded and spreading, not in one plane. The branches bear, and are developed from, elongate straight branchlets which bear four rows of pinnules. Two of the rows are closely packed as in *Aphanipathes pennacea* (Pallas); they arise from the lateral margins of a branchlet at right angles and are slightly recurved, particularly towards the apex. They are usually about 3·5 cm. long, and are not only found on the branchlets, but cover the main branches and portions of the stem as well. The other two rows of pinnules are not so numerous. They arise from the antero-lateral angles of a branchlet and spread over the main series, forming together two more or less well-defined double series passing the whole length of a branchlet (*cf.* Fig. 19). The pinnules of the upper series are never over 2·5 cm. in length but are usually shorter, and the members of each series are sometimes not so uniformly disposed in one plane as is the case with the lower and longer ones. The plumose branchlets vary in length from 14 to 23 cm. Some of the longer ones bear secondary plumose branchlets arising laterally and nearly at right angles; these are evidently enormously developed pinnules which have themselves become pinnate. The whole specimen measures 50 by 50 cm. The sclerenchyma has a rich golden brown colour, very different from the usual tint, and similar in this respect to *Antipathes spinescens*, Gray. The polyps were not observed. The spines are arranged in close, irregular, dextrorse spirals, and also in regular longitudinal rows, five of which may be counted from one aspect of a pinnule. The spines are rather long, subconical, with the base somewhat compressed. Most of the spines are bent upwards from a point near the base and have a number of coarse granulations distributed over their surface, some of which are pointed. The members of a row are from three quarters to one and a quarter lengths apart; all taper gradually to a sharp apex (Pl. XI. figs. 3, 3*a*).

Fig. 19.

Habitat.—Mauritius (Brit. Mus.).

Aphanipathes? wollastoni (Gray, MS.) (Pl. XI. fig. 6).

Antipathes subpinnata, Gray (*non* E. and S.), Proc. Zool. Soc. Lond., 1857, p. 293.

The whole specimen, which is without base, is about 56 cm. high, and broken into

several pieces. The diameter of the stem is a little over 6 mm. The mode of branching is irregular. The main branches bear smaller, straight, or slightly arched, branchlets, varying from 7 to 13 cm. in length, which have a series of simple pinnules 0·6 to 4 cm. long coming off from all sides of the axis and directed obliquely. These are not very closely set, and have a similar arrangement to those of *Parantipathes hirta* (Gray). A number of branchlets clothed with pinnules arise at intervals directly from the stem as well as from the main branches.

In the upper portions of the colony the terminal parts of the main branches appear like immensely developed branchlets, bearing pinnules for a length of 20 to 25 cm., some of which become elongate, thickened, and bear a secondary series of smaller pinnules. Here, evidently, we have the earlier condition of those pinnules which, in the older portion of the colony, have become much more elongate and thickened, and there form well-marked branchlets.

In one instance the terminal 14 cm. of a main branch bears ten branchlets in all, seven of which are lateral, the others anterior or posterior. They vary in length from 5 to 16 cm., and all form an acute angle with the branch. The shorter ones are very slender, and are evidently elongated pinnules which have become pinnate. The longer ones have a diameter of about 1 mm. at the base, and may bear one to three smaller branchlets. The pinnules are very irregular in length and arranged spirally; there are from three to five to a centimetre, the average length being about 2 cm. The spines are long and slender, having a sharp bend near the base, so that the apical portion of the spines takes a subvertical direction. The spines are arranged in regular longitudinal rows, six or seven of which may be counted from one aspect of a pinnule. They are also arranged in irregular spirals, which may be dextrorse, but a spiral in the opposite direction is almost equally well marked. The members of a row are about one length apart. Each spine is about equal in length to the diameter of a pinnule; the base is broad and thick, the apical portion usually slender, with a sharp point (Pl. XI. fig. 6).

This is the species which Gray referred to *Antipathes subpinnata*, E. and S. It differs essentially from that species in the arrangement of the pinnules and in the form of the spines. It is placed in the genus *Aphanipathes* provisionally, but the polyps are not known; it seems, however, to possess a more elongate type of spine than is found in *Antipathella*, and appears related in the form of corallum to a number of West Indian species which have an obscure polyp. The specimen described by Gray bears the manuscript name "*Antipathes Wollastonii*," which it appears desirable to retain. Gray (*loc. cit.*) remarks that he at first regarded this specimen as distinct and named it *Antipathes wollastoni*, but that later he regarded it as a variety of *Antipathes subpinnata*, E. and S. His description of *Antipathes subpinnata*, therefore, refers to this specimen and not to the type of Ellis and Solander. Another specimen in the British

Museum Collection, from the Iles Salvages (south of Madeira), appears to agree in all essential points with the type, but has a more slender stem and main branches.

Habitat.—Madeira and Iles Salvages (Brit. Mus.).

Aphanipathes? barbadensis, n. sp. (Pl. II. fig. 10 ; Pl. XI. fig. 4).

A small species with a simple erect stem bearing five rows of subhorizontal pinnules, recalling the habit of *Parantipathes larix*, from which, indeed, it is indistinguishable at first glance. There are, however, only five rows of slender pinnules instead of six, and only those arising from the upper portion of the stem are simple. The lower pinnules bear one or two short, simple or forked, secondary processes which are turned downwards, and situated near the base of each pinnule (Pl. II. fig. 10). The stem is 30 cm. long, and the pinnules vary from 1·3 to 2·5 cm., with an average length of about 2 cm. The spines are strong, elongate, much compressed, and arranged in irregular, steep, dextrorse spirals as well as in longitudinal rows. Six rows may be counted from one aspect of a pinnule, the members of a row being about one length apart (Pl. XI. fig. 4). The short secondary pinnules of this species recall the more complicated arrangement in *Parantipathes hirta* (Gray), but the spines are of quite a different type. The elongate crowded spines appear to indicate a relation to the genus *Aphanipathes*, but the polyps are not known.

Habitat.—Barbadoes (Brit. Mus.).

Aphanipathes? pedata (Gray) (Pl. XI. figs. 12, 12*a*).

Antipathes pedata, Gray, Proc. Zool. Soc. Lond., 1857, p. 291.

The following is Gray's description of this interesting species :—

"Coral fan-like, in one plane, branched ; branchlets linear elongate, in one series on the upper side of arched branches, and branched on the inner side."

I find from an examination of the type specimen, which is in the British Museum, that this specimen is parasitic in its habit, a feature of special interest, as it is, so far as I am aware, the only known instance amongst the Antipathidæ. The stem and main branches possess a central core of wood—evidently a small branch and twigs of some tree—on which the young oozooid has fixed itself, and made use of the ligneous axis for the earlier extensions of its colony, as is the case in *Savaglia lamarcki*. The wood is only covered by an extremely thin dull brown sheath of sclerenchyma, on which the spines are developed in the normal manner. The corallum evidently attains a large size, the type specimen, which is broken into several pieces, being over 1 metre high. The diameter at the base is over 7 mm., and the main stem gives off a number of principal

branches at distances of from 2·5 to 7·5 cm., which are chiefly confined to one side of the stem. These, in turn, give rise to a smaller series of branches, nearly all of which are somewhat curved or arched. Probably the whole stem, primary and secondary branches, have a central ligneous axis, and thus offer a mode of branching which is not characteristic of the species. The curved secondary branches bear a number of slender, elongate, and perfectly straight rigid branchlets on their upper surfaces. These are usually 6 to 8 mm. apart, and form an acute angle (about 40° to 45°) with the branches from which they arise. The branchlets again bear on their upper (inner) surfaces a series of similar secondary branchlets or pinnules, which in turn occasionally bear a third series of a similar type. The latter two series of slender branchlets are generally directed vertically. The ultimate branchlets are usually collected into subtriangular fan-like clusters, which remain comparatively isolated from each other. The whole corallum extends chiefly in one plane, and there is no indication of fusions or adherences at any point, indeed the branchlets rarely overlap each other.

The spines are subcylindrical, of medium length, and usually have a blunt apex. They are usually inserted at an acute angle, and the whole spine from the apex to near the base is covered with rough sharp protuberances. In this respect the spines approach those of *Aphanipathes alata*, but they have not such a sharp apex. The spines do not show any apparent spiral arrangement, but are arranged in longitudinal rows, five or six of which may be counted from one aspect of a pinnule. The members of a row are one to one and a quarter lengths apart (Pl. XI. figs. 12, 12*a*). The specimen being dry, I have not been able to study the polyps, but these are indicated on the branchlets as a linear series of small rounded protuberances, about seven or eight to a centimetre.

Habitat.—West Indies (Scrivener), Brit. Mus.

Aphanipathes? pennacea (Pallas) (Pl. XI. fig. 23.)

Antipathes pennacea, Pallas, Elenchus Zooph., p. 209; Lamouroux, Polyp. flex., p. 379; Encyclop. méthod., p. 71; Dana, Zooph., p. 582; Milne-Edwards, Coralliaires, t. i. p. 318.
? Antipathes pluma, Gray, Proc. Zool. Soc. Lond., 1857, p. 291.

"A. ramosa subincurva, ramis pennatis, pinnulis setaceis creberrimis hispidis" (Pallas, *op. cit.*).

Gray gives the following short description of his *Antipathes pluma*:—"Coral fan-like, branched, forked; branchlets pinnate, simple, in two opposite diverging series; spinules very closely crowded." He gives no locality. I have not been able to find any specimen in the British Museum bearing the name *Antipathes pluma* on the label, but an unnamed specimen from St. Helena may be the one referred to. A comparison of this and other specimens in the British Museum, with a specimen of *Antipathes*

pennacea, Pallas, from the Paris Museum, has led me to suppose that all belong to one species, for which it is necessary to retain the specific name proposed by Pallas.

The St. Helena specimen is dull greenish grey in colour, and bears beautiful feather-like branches which extend in various directions. Each branch consists of a straight axis, from 4·5 to 10 cm. long, bearing a double row of simple and subequal pinnules which are alternate and close together. There are usually about twelve to a centimetre. The pinnules are somewhat flattened, and are usually about 2·5 cm. long, though an occasional one here and there may be 1 to 1·5 cm. longer. All are simple in this specimen. In the Paris specimen the arrangement is the same, excepting that on some of the branches one or two of the pinnules become elongate and pinnate.

Another specimen approaches *Aphanipathes alata* in habit, but has, of course, only two rows of pinnules instead of four. The plumose branches are 4 to 15 cm. long, and the pinnules are not so regular in size as in the other specimens referred to. They vary from 2 to 4 cm. in length. On many of the branches certain of the pinnules, often on the same side, become more elongate, and bear a secondary series of alternate pinnules. The spines are very long and crowded. Each spine has a moderately broad base; it then becomes much compressed, and the upper and lower margins are nearly parallel for the greater part of their course, when the spine quickly tapers to a sharp point. They are arranged in longitudinal rows and probably also in dextrorse spirals. The spines have a length equal to about two and a half times the diameter of a pinnule. The members of a row are less than one length apart.

Habitat.—East Indies (Pallas); St. Helena (Brit. Mus.).

Aphanipathes? eupteridea (Lamx.).

Antipathes Euptiridea, Lamouroux, Encyclop. méthod., p. 71; Duchassaing, Rev. d. Zooph. et d. Spongiaires des Antilles, 1870, p. 22; M.-Edwards, Coralliaires, t. i. p. 315.
Antipathes eupteridea, Pourtalès, Bull. Mus. Comp. Zoöl., 1880, p. 117, pl. iii. fig. 11.

Sclerobasis in simple branches, nearly triangular; pinnules simple, spinose, and elegantly incurved. Lamouroux compares his specimen to a peacock's feather. Duchassaing merely mentions the species as occurring in the West Indies.

Pourtalès obtained a specimen off Martinique, which he considered referable to this species. He compares the branching to that of some Plumularidæ (*e.g.*, *Cladocarpa paradisea*, Alln.). The main stem, which was dead at the top, must have been 40 to 50 cm. high. Pinnules alternate, about 40 mm. long. Spines nearly cylindrical, rather dense, subequal, very little larger about the polyps. The polyps are very small and "sessile."

Habitat.—Off Martinique, in 96 fathoms (Pourtalès). The type specimen came from the same area.

Aphanipathes? humilis (Pourt.).

Antipathes humilis, Pourtalès, Bull. Mus. Comp. Zoöl., 1868, p. 112; Cat. Mus. Comp. Zoöl., No. iv., 1871, p. 54; *Ibid.*, No. viii., 1874, p. 46, pl. ix., fig. 9; Bull. Mus. Comp. Zoöl., 1878, p. 210; *Ibid.*, 1880, p. 118, pl. iii. figs. 18, 19, 32.

Mode of branching dense and irregularly subflabellate, like a spray of heather; branches irregularly dichotomous, spreading more laterally than vertically, height 7·5 to 10 cm., spread 10 to 12·5 cm. Spines slender, and longer than the diameter of the branch, very dense, forming alternate dilations and contractions, each dilation corresponding to a polyp.

Polyps all on the same side of the flabellum, about one diameter apart. Tentacles very short, when contracted forming small knobs, shorter than the spines, and placed in two longitudinal rows, with the mouth between the middle pair. The spines surrounding the polyp larger than in other parts, and largest inside the polyp, in the spaces between the tentacles. Mouth surmounting a tubercle, surrounded by about twelve papillæ in a close circle; a second circle of papillæ occurs on the peristome just inside the tentacles, and similar ones are scattered on the whole surface of the ectoderm.

A variety dredged off Barbadoes differs from the type by its more simple and regular mode of branching. The short stem throws off on each side at different heights a simple branch forming a short curve and then growing parallel to the main stem. From the base of that branch another sets off in the same manner, and so on, so that the whole resembles certain fruit trees trained on a wall. The type specimens branch according to the same plan, but do not adhere to it so regularly. Pourtalès gives a photograph of this variety in his Catalogue of Corals (pl. ix. fig. 9), which suggests at once the habit of *Eunicea succinea*, Esp.

The arrangement of spines in this species is most curious. The axis is clothed with a dense mass of acicular spines, which on the posterior surface are relatively short and directed upwards. On the zooidal surface of a branch they form dense moniliform tufts, each corresponding to a polyp. The tufts are oval in outline, and consist of innumerable elongate spines radiating in all directions. The polyps in spirit specimens are almost completely hidden amongst the elongate spines, which project for a considerable distance beyond the surface of the peristome.

Habitat.—Abundant off Havana in 270 fathoms; also in 76–262 fathoms at four stations off Montserrat, Grenada, St. Vincent, and Barbadoes (Pourtalès.)

Aphanipathes? thyroides (Pourt.).

Antipathes thyroides, Pourtalès, Bull. Mus. Comp. Zoöl., 1880, p. 115, pl. iii. figs. 17 and 31.

Corallum densely flabellate, but entirely without adherences of branchlets, which ramify from the sides of the branches without showing any regular pinnate arrangement.

The finer branches show an apparent succession of swellings produced by the larger spines surrounding the polyps. Spines cylindrical, unequal, with a few very long ones about the proximal end of each polyp. The polyps (of which Pourtalès gives a figure) are sessile, with very short tentacles. The largest specimen spreads 20 cm. in height and 30 cm. in breadth (Pourt., *op. cit.*).

I judge from the above description that this species is somewhat allied in mode of branching to *Aphanipathes? fruticosa* (Gray). It differs considerably, however, in the size and arrangement of the spines, of which Pourtalès gives a figure. The spines are all of the same type, but those in the neighbourhood of the polyps are more elongate, giving a submoniliform appearance allied to that of *Aphanipathes? humilis* (Pourt.), but not nearly so pronounced. In *Aphanipathes? fruticosa* (Gray), on the other hand, the spines are of two very distinct sizes, each regularly distributed and apparently subject to little variation in length. In the form and arrangement of spines this species comes nearer to *Aphanipathes filix* and *Aphanipathes abietina*, but differs from both in the type of branching.

Habitat.—Off St. Vincent, 124 fathoms (Pourtalès).

Aphanipathes? filix (Pourt.).

Antipathes filix, Pourtalès, Bull. Mus. Comp. Zoöl., 1868, p. 112; Cat. Mus. Comp. Zoöl, pt. iv., 1871, p. 54; Bull. Mus. Comp. Zoöl., 1880, p. 116, pl. iii. figs. 15, 16.
Antipathes myriophylla, Pourtalès (*non* Esper.), Bull. Mus. Comp. Zoöl., 1878, p. 210; non *Antipathes myriophylla*, Esp., Pourtalès, Bull. Mus. Comp. Zoöl., 1880, pl. iii. fig. 23.

Young Specimens.—Main stem erect, straight, pinnate; pinnules set off nearly at right angles, rather short, covered with spines or short stiff hairs, and showing a succession of slight swellings and contractions. Axis tough and corneous, nearly black, dark amber colour by transmitted light, about 7 cm. high.

Older specimens branch in a subflabellate manner, spreading 30 to 40 cm. more in breadth than in height, and assuming the general appearance of *Antipathes myriophylla*, Esp., with which Pourtalès says he confounded it when in this state. "It differs from the latter greatly in the arrangement of the pinnules and spines. The long spines surrounding the polyp are beset with little knobs at the end, giving them a rugose appearance." The polyps are small and inconspicuous, of the *Aphanipathes humilis* type.

According to Pourtalès, the differences between this species and *Aphanipathes abietina* are not great, the spines and polyps presenting no particular differences. The former may be distinguished (if not a mere variety) by its greater stiffness and by being regularly pinnate, instead of having pinnules in every direction.

Habitat.—Off Havana, in 270 fathoms,—every specimen obtained served as support

for the tubes of an Annelid (*Marphysa antipathum*); also in 76 to 287 fathoms at twenty stations off Montserrat, Martinique, Dominica, Guadeloupe, St. Vincent, the Grenadines, and Barbadoes (Pourtalès).

Aphanipathes? abietina (Pourt.).

Antipathes abietina, Pourtalès, Cat. Mus. Comp. Zoöl., pt. viii., 1874, p. 47, pl. ix. fig. 10; Bull. Mus. Comp. Zoöl., 1878, p. 210; *Ibid*, 1880, pl. iii. fig. 14.

Stem simple or emitting a few simple branches from the base, stiff erect, hirsute, beset with short pinnules on all sides, not verticillate. This is the principal difference from *Aphanipathes filix*, which is pinnate. Pinnules nodose, beset with cylindrical spines. The polypsare of the short-tentacled type surrounded by larger spines than those on the rest of the pinnule. Height 10 cm. Pinnules about 1 cm. long. Every specimen has one ortwo worm tubes attached to the stem as in *Aphanipathes filix*.

Habitat.—Off Barbadoes, 100 fathoms (Pourtalès).

Aphanipathes cancellata, n. sp. (Pl. III. figs. 5–9).

The corallum forms a flat close-set reticulum extending more in breadth than in height. The larger of the two specimens included in the Challenger collection is 26 cm. high and 55 cm. broad. A few centimetres above the base the branches extend horizontally, so that the maximum breadth is quickly reached. A main stem is absent in this species. A number of short strong branches arise from the dilated base, and passing upwards and outwards soon become so reduced in diameter as to be indistinguishable amongst the numerous branchlets. There are no other strong branches passing through the corallum in various directions which might give a clue to the mode of branching. Nearly the whole of the corallum consists of slender branchlets, which subdivide irregularly and are united to neighbouring branchlets by means of short transverse or oblique pinnules about 0·3 to 1 cm. in length and having a similar diameter to the branchlets from which they are developed. The arrangement of the branchlets and pinnules near the centre of the corallum as they appear clothed with polyps and cœnenchyma is shown on Pl. III. fig. 6, which is twice the natural size. In the middle portion of the corallum the branchlets have a general subvertical course; laterally they extend more obliquely, whilst near the base they take a subhorizontal direction. Near the apex of the corallum the branchlets taper quickly and the pinnules are more slender (Pl. III. fig. 7). Many are short and acicular, but with greater elongation they become thickened and bear from one to six lateral and subalternate processes, indicating a transition to the branchlet form. The base and the strong branches springing from it

are a glossy black, but in all other parts the sclerenchyma has a uniform reddish brown colour. The spines are moderately long, round, and taper slowly to a sharp point. Each spine is covered with numerous small sharp-pointed processes to near its base. The spines are rather crowded and extend subhorizontally, or some may be tilted up at an acute angle with the axis. No well-marked spiral arrangement is observable, but six longitudinal rows may be counted from one aspect of a pinnule (Pl. III. figs. 8 and 8*a*). The members of a row are a little over one length apart.

The polyps (Pl. III. fig. 9) vary considerably in size, those on the branchlets being usually larger and more distant than those on the pinnules. The whole of the peristome within the tentacles forms a large mammiform process, on the centre of which the mouth opens. The mouth is usually, but not invariably, elongated in the sagittal axis; sometimes the aperture is dumb-bell shaped. The tentacles form six small tubercles arranged radiately around the mouth, or in elongate polyps they form three pairs, viz., two lateral pairs, which are close together, and a sagittal pair; the two members of a pair are separated in each case by the diameter of the peristome. In spirit preparations the spines project freely through the cœnenchyma, and in many cases also through the zooidal tissues. A comparison of the shape of the polyps situated on the pinnules with those on the branchlets would lead one to suppose that during the growth of the colony the polyps when at first formed have an elongate outline, but that afterwards, with an increase in the thickness of the axis, a more radiate outline is assumed. Apparently the polyps, which are about twice as broad as long on the pinnules, attain their full diameter in the transverse axis in such situations. Later, with an increase in the thickness of the sclerenchyma, the diameter in the sagittal axis gradually increases until the outline is practically round. The polyps on a pinnule may be crowded or relatively far apart; those on the branchlets are usually about one diameter apart.

Habitat.—Station 192; September 26, 1874; lat. 5° 49′ 15″ S., long. 132° 14′ 15″ E., off Ki Islands; depth, 140 fathoms; bottom, blue mud. Two specimens.

Genus *Tylopathes*, n. gen.

? *Antipathes* (*pars*), Pallas, &c.
? *Rhipidipathes* (*pars*), M.-Edw.

Polyps small and isolated, appearing as oval or oblong cushion-like elevations on the cœnenchyma. The mouth is situated on a small median prominence and is usually slit-like. The tentacles are moderately long, or may be reduced to very short knobbed elevations of the margin of the peristome. The polyps are somewhat of the *Aphanipathes* type, but, though flattened, their contour is never obscured by projecting spines. The reproductive elements are contained in specialised bands of cells attached to the stomodæum and body-wall as in the genus *Antipathes*.

The corallum may consist of irregular plumose branches, amongst the smaller twigs of which occasional fusions occur, or (?) of a flattened fan-like reticulum. The spines are short and subtriangular or subcylindrical, never elongate and conical. The type species differs from *Aphanipathes* in the form and structure of the polyp as well as in the type of spine. *Antipathes flabellum*, Pallas, and a number of new species which are apparently allied to it, agree with *Aphanipathes cancellata*, n. sp., in having a fan-like reticulate corallum (which, however, is constructed on a different plan), but differ altogether in the type of spine. The polyps of these species are not known, but as the spines have a close resemblance to those of *Tylopathes crispa*, n. sp., I have provisionally included them under the same genus. It should, however, be noted that the genus *Antipathella* has a similar form of spine, but the mode in which the reticulum is formed in *Antipathes flabellum*, Pall., and the allied species, seems more nearly related to that in *Tylopathes crispa*, n. sp., than to the flabellate forms at present included in the genus *Antipathella*.

Tylopathes crispa, n. sp. (Pl. III. figs. 1–4).

In this species the chief branches, and the smaller ones which they bear, are crisped and arched inwards, forming saucer-like fronds, depressed in the centre, and having the majority of the branchlets and pinnules directed inwards.

The Challenger specimen consists of a number of fronds which have been detached from the stem or main branches. These may be 14 cm. long and 22 cm. broad. The chief branch of a frond bears a number of smaller branches, irregularly arranged, which are sometimes lateral, but more usually antero-lateral in position. The smaller branches vary from 4 to 12 cm. in length. Each bears a number of branchlets of variable length, but usually more elongate and crowded near the apex of a branch. These arise generally from a point somewhat in front of the true lateral margin, and are from 2 to 6·5 cm. in length. These again bear a very large number of simple or branched pinnules, varying from 0·3 to 2 cm. in length. The pinnules are arranged irregularly all around the axis of a branchlet, but only those which have a lateral or antero-lateral position become elongate and further subdivided. Near the base of a branchlet all the pinnules are short and simple or subsimple; those about 5 mm. long may bear one short secondary pinnule; others, about 7 mm. long, bear three or four secondary pinnules in various planes, but between them there are always a few arising from the anterior, posterior, or lateral surfaces which remain simple. The antero-lateral pinnules arising from the upper half of a branchlet are often longer; all bear numerous secondary pinnules which extend in various planes, and the longer secondary pinnules usually bear one or two of a tertiary series. One branchlet, 5·5 cm. in length, bears altogether about seventy pinnules, about thirty of which are more or less branched. The longer primary pinnules bear about twelve secondary pinnules to a centimetre (Pl. III. fig. 1).

The branchlets and pinnules in certain portions of the corallum are modified to form a long cylindrical reticulum which serves as the habitation of an Annelid (Pl. III. fig. 2). In such portions the lateral pinnules arch over so as to meet above, and are connected together by numerous bridge-like processes, the whole forming a close tubular reticulum. The pinnules of adjoining branchlets are often united together at various points, but there is no regular reticulum formed, excepting in the case of the worm-tubes already referred to. The type of corallum is intermediate between that of certain paniculate species of *Aphanipathes* and the fan-like reticulate species, such as *Tylopathes? flabellum* (Pallas).

The spines are short and subtriangular, with a sharp apex. The upper margin may be concave or almost straight. A spiral arrangement is not well marked, but an irregular steep dextrorse spiral may be sometimes observed. The spines are arranged in regular longitudinal rows, six of which may be counted from one aspect of a pinnule. The members of a row are from two to two and a half lengths apart (Pl. III. fig. 4).

The cœnenchyma has a dirty yellow colour washed with light brown. The polyps are of a deep rich brown colour, excepting a circular area, including the mouth, which is white. The polyps are elongated in the transverse axis, being usually about twice as broad as they are long; there appears to be no marked tendency for the polyps to assume a rounded outline on the stronger portions of the corallum. On the pinnules the polyps usually form a single row, which, however, is not always confined to one aspect. On the branchlets the polyps rarely form a single series, they are sometimes arranged irregularly, but often two rows are formed, in which case the polyps are arranged in pairs on opposite aspects of a branchlet. The tentacles in living specimens are evidently of moderate length. In spirit preparations most of them become reduced to small rounded elevations of the peristome, which recall the appearance in *Aphanipathes*. Some, however, are better preserved, and appear as conical processes having a length about equal to that of the polyp (Pl. III. fig. 3). Often four tentacles are all that appear to remain in old individuals, the sagittal tentacles having atrophied. A comparison of a number of specimens has led me to suppose that after a time the sagittal tentacles leave their normal position at the margin of the peristome and sink to a lower level, after which they become reduced in size and ultimately disappear. The lateral pairs of tentacles next become reduced, apparently without changing their position. Specimens which possess only two tentacles are not rare. Ultimately all disappear, and in the older portions of the corallum the position of a polyp is often only to be recognised by the white circular area on which the mouth opens.

Habitat.—Station 310; January 10, 1876; lat. 51° 27′ 30″ S., long. 74° 3′ 0″ W., Sarmiento Channel; depth, 400 fathoms; bottom, blue mud.

Tylopathes? flabellum (Pallas), *non* Esp. (Pl. XI. fig. 18).

Antipathes flabellum, Pallas, Elench. Zooph., p. 211; Lamarck, Hist. nat. anim. sans vert., t. ii. p. 309; Lamouroux, Polyp. flex., p. 382; Dana, Zooph., p. 579.
Rhipidipathes flabellum, Milne-Edwards, Coralliaires, t. i. p. 321.

"A. explanata ramosissima subdivisa, ramulis bifariam ramosis, reticulatim cohærentibus. Lignum stirpis fragilissimum, atrum, tenerrima scabritie hispidum. Calyces a latero convexo flabelli, per ramos sparsi, crebri, grano papaveris vix majores, breviculi, subturbinati, extus scabri" (Pallas, *op. cit.*).

In its flattened and trellis-like surface this species has much the habit of *Rhipidogorgia flabellum*, indeed the form described and figured by Esper may have belonged to this or some allied species, as the axis was smooth and devoid of spines.

A specimen in the British Museum from Madagascar, which appears to be referable to this species, has a form that is perhaps due to some injury received during growth. The corallum is flattened, but in the middle it becomes folded, so that a flattened plate-like portion grows out at right angles to the general plane of growth and parallel with the axis of the stem. The lower branches come off irregularly, and are fused together by bridges of sclerenchyma which cross obliquely from one to another. In this portion of the colony the sclerenchyma is black and polished, but bears a number of small slender spines only seen by the aid of a lens. In the upper part of the corallum the long slender branches run almost vertically and are closely set (4 to 10 mm. apart). These are reddish brown in colour and more densely spinose. They bear pinnules given off subalternately from the antero-lateral margins, which are bent upwards and usually fuse with those from an adjoining branch. The pinnules are 3 to 6 mm. long and generally simple, though some of the larger ones bear secondary pinnules springing from the antero-lateral margin and usually free. With these exceptions the whole of the subdivisions from base to apex are fused into a close reticulum, consisting of long slender subvertical branches and close-set antero-lateral pinnules, so that the surface of the corallum following the pinnules has a zigzag outline. The spines are moderately long, and arranged in subregular dextrorse spirals and also in longitudinal rows. Five rows may be counted from one aspect of a slender branchlet, the members of a row being from one and a half to two lengths apart. The spines are about twice as long as broad at the base, and slowly taper to a moderately sharp point. Most of the spines form a right angle with the axis, but those in certain rows are hooked upwards (Pl. XI. fig. 18).

Habitat.—Indian Ocean (Pallas); off Madagascar (Brit. Mus.).

Tylopathes? dubia, n. sp. (Pl. XI. fig. 15).

The corallum consists of a loose fan-like network of branchlets and pinnules, forming a reticulum of the same type as that in *Tylopathes flabellum* (Pallas), but much more irregular. There is very little difference in thickness between the branchlets and pinnules; the latter are longer, stronger, and less numerous than in *Tylopathes flabellum* (Pallas). The branchlets are slender, have an irregular course, and bear arched pinnules subalternately. The pinnules are lateral or antero-lateral in position, and are more or less arched inwards; they vary from 4 to 8 mm. in length, and there are seven or eight to a centimetre, most of which form a wide angle with the branchlet from which they spring. In many cases a pinnule becomes much elongated (1·5 to 2·5 cm.), often without appreciably increasing in thickness, and becomes bent upwards, so as to fuse with a number of the pinnules above it. Three such elongated pinnules may occur in one centimetre and have a similar course; all bear secondary pinnules, some free, others fused with adjoining pinnules. On this account the subdivisions of a branchlet frequently extend for a distance of 1·5 cm. or more on one side of it or on both. The branchlets are thus not so near together nor so regularly vertical in their course as in *Tylopathes flabellum* (Pallas), and the resulting reticulum is not so distinctly pinnate. The spines are conical, with a rather broad base and sharp apex. They are arranged in regular dextrorse spirals, similar to those of *Tylopathes flabellum*, but the members of a spiral are fully one length apart (Pl. XI. fig. 15). Six longitudinal rows may be counted from one aspect of a pinnule, the members of a row being about two lengths apart. The type specimen consists of only a portion of a colony, and is 10 cm. high and 8 cm. across the broadest part. It undoubtedly comes near to Pallas' species, but the mode of branching, coupled with the thicker pinnules and smaller number of spines, appear to afford sufficiently distinctive characters.

Habitat.—Off Inosima Island, Japan (Burge), Brit. Mus.

Tylopathes? hypnoides, n. sp. (Pl. XII. fig. 4).

Corallum fan-like, 23 cm. high and 28 cm. broad; branches irregular and spreading, with frequent fusions. Branchlets usually 2·5 to 5 cm. long, bipinnate, both series of pinnules arising at a point in front of the exact lateral margin. The primary pinnules are arranged subalternately, but vary in length. Many are relatively short (6 mm.) and simple, but between every two or three of these, larger ones arise (1·3 to 2 cm.) which are pinnate, whilst in some cases certain of the secondary pinnules bear one or two short tertiary pinnules on their outer margins. The effect of this arrangement gives each

terminal branchlet the appearance of a frond of *Hypnum*. The subdivisions of the terminal branchlets are usually all free. The branchlets are relatively thick, and taper quickly towards the apex. They have a deep glossy brown or black colour. The pinnules are slender, and have a greenish yellow tint, becoming pale yellow near the apex of the secondary pinnules.

The spines are relatively distant, and arranged in very steep, regular, dextrorse or sinistrorse, spirals; the spiral appears to follow almost equally well either way. The spines are moderately long, about three-quarters the diameter of a pinnule, and are subconical and compressed, with the apex often slightly bent upwards. Five longitudinal rows may be counted from one aspect of a pinnule; the members of a row are about two lengths apart.

Habitat.—Mauritius (Brit. Mus.).

Tylopathes? elegans, n. sp. (Pl. XI. fig. 16).

Corallum delicate and web-like, not in one plane, forming a reticulum similar to that of *Tylopathes hypnoides* but much more delicate. The branchlets are very slender and scarcely tapering, and are only slightly thicker than the pinnules. They vary from 3 to 5 cm. in length, and are of similar diameter to the older portions of the axis from which they arise. They bear a number of subalternate pinnules of variable length, about thirteen to a centimetre. These are rarely lateral in position, and vary from 0·3 to 2 cm. in length. Those over 0·5 cm. long generally bear one or more secondary pinnules; the longest ones bear a dozen or more subalternately, the longest of which may be 0·5 cm. in length. The arrangement is similar to that in *Tylopathes hypnoides*, but the terminal fronds are much broader on account of the greater length of certain primary pinnules. There is also no marked difference between the thickness of the branches and branchlets, the whole specimen being unusually delicate. The branchlets are rarely straight, and sometimes adjoining ones are curved in opposite directions so as to cross one another almost at right angles. The terminal fronds have a somewhat lax hypnoid growth, but the pinnules become fused with those from neighbouring branchlets quite close to the apex of the corallum. The sclerenchyma has a light reddish brown colour in all parts. The type specimen is 12 cm. high and 12 cm. across the broadest part; the base is not preserved. The spines are similar in shape to those of *Tylopathes hypnoides*, but are arranged in closer spirals from left to right. They are also arranged in longitudinal rows, six of which may be counted from one aspect of a pinnule. The members of a row are two lengths or more apart, and the spines in some rows are rather longer than those in others.

Habitat.—Kurrachee (Murray), Brit. Mus.

Genus *Pteropathes*, n. gen.

The polyps are arranged in a single linear series confined to one aspect of a branch. They are so closely crowded that there is no cœnenchyma on the zooidal surface of the axis, and the line of demarcation between two adjoining polyps passes straight across. In front view the polyps have a rectangular outline, and an elongation in the transverse axis is never marked. The tentacles are fleshy fusiform processes, but frequently in spirit preparations become much contracted. They are arranged in pairs, the two lateral pairs being parallel to one another and rather near together, though not so close as in the genus *Aphanipathes*. The sagittal tentacles are inserted at a very much lower level than the others, and are often not visible from the anterior surface. The peristome is relatively flat around the mouth, and the lateral tentacles spring from it. The sagittal tentacles, however, are inserted at a point opposite the centre of the sclerobasic axis, and between them and the margin of the peristome there is a deep cleft. The sagittal tentacles when fully developed are rather larger and thicker than the others, but in spite of this fact they are the earliest to atrophy. Polyps with only four tentacles are of frequent occurrence. The stomodæum is elongated in the sagittal axis, and the ectoderm clothing its inner wall is thrown into irregular folds. These usually become elongate tubular processes at a little distance below the oral aperture, and have a lumen opening into that of the stomodæum. The convolutions of the stomodæum occupy a position which, in the main, is parallel to the sagittal axis of the polyp, and are sometimes more complex at one extremity of the stomodæum than at the other. The reproductive elements are contained in specialised bands of cells attached to the stomodæum and body-wall, and occupy almost the whole of the cœlenteron. The only known species has a laxly-branched corallum with very long and close-set spines. The polyps do not project much beyond the surface of the cœnenchyma, but are more prominent than those of *Aphanipathes*.

Pteropathes fragilis, n. sp. (Pl. IV. figs. 1–4; Pl. XIV. fig. 4).

Corallum with a rounded basal dilation for attachment. Stem, near the base, under 2 mm. in diameter; above slightly over 2 mm., on account of the greater length of the spines. The specimen is broken into several pieces—total height probably 45 cm. or more. The stem bears a number of distant elongate branches, irregularly arranged, 5 to 15 cm. long, simple, or bearing one, rarely two, branchlets. The branches are usually distant and of a diameter only slightly less than that of the stem. They are usually lateral, rarely opposite, and occasionally a branch springs from the posterior surface of the stem. Some of the lower branches form a very wide angle with the stem; others, parti-

cularly in the upper portion of the colony, arise at a very narrow acute angle. The apex of the stem is broken off; near the point of fracture is an elongate branch, 14 cm. long, bearing only one branchlet, 6 cm. long, about the middle. The succeeding twelve centimetres bear eight branches, five of which are on the same side; one springs from the posterior surface, and two are subopposite. Branches up to 10 cm. in length are usually simple, longer ones generally bear one branchlet, which is usually simple. In certain cases a branchlet may be almost as long as the branch from which it springs, in which case it bears a secondary branchlet. The ultimate branchlets are from 4 to 6 cm. long. The whole axis is only very slightly tapering, and there is, practically, no difference between the diameter of a branchlet and of the branch from which it arises. The sclerenchyma is black or dark brown, very slender and fragile, and clothed with a large number of very long slender spines, which materially add to the apparent thickness of the axis. The spines are not disposed in regular spirals but form longitudinal rows, of which six may be recognised from one aspect. The members of a row are separated by an interval fully equal to the length of the spines comprising it. All are subequal in length, but those in one row are sometimes broader at the tip than those of an adjoining row. All are very long, considerably longer than the diameter of the axis. In form they are of the "cylindrical" type. The base is very broad, about half the length, and somewhat compressed laterally. The tapering portion is gently curved upwards.

The form of polyp has been described amongst the generic characters. All are closely packed, with no space for lateral prolongations of their cœlentera. About five usually occur to a centimetre. The sagittal tentacles disappear first, and in the older portions of the colony the polyps have only four tentacles, namely those bordering the transverse axis.

In the mode of branching this species probably comes near to *Aphanipathes thyroides* (Pourt.), but differs in the form of polyp and in the spines, which in the latter are irregular in length and more elongate in the region of the polyp. The branching has much in common with *Aphanipathes sarothamnoides*, n. sp., and comes still nearer to *Antipathes mediterranea*, n. sp. In both cases the form of polyp and the shape and arrangement of the spines afford sufficiently distinctive characters.

Habitat.—Off St. Paul's Rocks, in 10 to 80 fathoms; August 28, 1873.

Genus *Parantipathes*, n. gen.

Antipathes (*pars*), Auctt.

Polyps very much elongated in the transverse axis, *i.e.*, in the direction of a branch. In *Parantipathes larix* the transverse diameter is three or four times as great as that in the sagittal direction. The tentacles are slender and elongate, and appear to be arranged in

pairs, which are a considerable distance apart, the two forming an apparent pair being close together on opposite sides of a branch. According to the view which I have taken of the homologies of the mesenteries, the lateral pairs must, however, be considered to consist of two tentacles on the same side of a branch, that is to say, a pair of lateral tentacles is situated on each side of the pair of transverse mesenteries, and the greater the elongation of a polyp the more the two tentacles, which morphologically form a pair, become removed from one another. The mouth is somewhat elongated in the sagittal axis, but the stomodæum, particularly in its lower part, has frequently a greater diameter in the transverse than in the sagittal direction. There are ten mesenteries in the oral cone and six below. The transverse pair of mesenteries are very long, and correspond to the elongation of the zooid. The peristome usually presents a slight depression on each side of the oral cone where the transverse mesenteries are partly reduced, but there is no indication of a vertical mesoglœal septum as in the Schizopathinæ. The reproductive elements are borne only on the distal portions of the transverse mesenteries. The spines are short and very distant, frequently appearing like short pointed tubercles, but at other times they are longer, and triangular or hooked upwards.

The corallum in the type species and also in *Antipathes tetrasticha*, Pourt., which probably belongs to the same genus, consists of a simple or rarely branched stem with simple spiral or verticillate branches. It is interesting to note that another species (*Aphanipathes? barbadensis*, n. sp.), the polyps of which are not known, has a similar form of corallum, but the spines are of such a different character that in the absence of more definite information I have considered it necessary to refer it to another genus.

Parantipathes larix (Esper) (Pl. XII. fig. 20; Pl. XIII. fig. 2; Pl. XV. fig. 1).

Antipathes larix, Esper, Pflanzenth., Fortsetz., pt. ii. p. 147, pl. iii.; Lamarck, Hist. nat. anim. sans vert., t. ii. p. 308; Lamouroux, Polyp. flex., p. 374; Encycl. méthod., t. iv. p. 70; Risso, Hist. nat. de l'Europ. méridionale, t. v. p. 330; Blainville, Manuel d'Actinol., p. 551; Dana, Zooph., p. 577; Milne-Edwards, Coralliaires, t. i. p. 315; Gray, Proc. Zool. Soc. Lond., 1857, p. 292; Lacaze Duthiers, Ann. Sci. Nat. (Zool.), sér. 5, t. iv. pp. 49–52, pl. iv. figs. 23–25; v. Koch., Morph. Jahrb., Bd. iv. pp. 74–78, pl. i.

Stem erect, simple, or rarely branched near apex, bearing six rows of close-set, spirally arranged, simple pinnules, almost at right angles, each row in a plane. Spines short, distant, subconical, and often hooked upwards, not all of the same size.

The largest specimen with which I am acquainted (Brit. Mus. Coll.) measures 1·3 m. in length, and has a diameter of nearly 8 mm. at the base. In this specimen the stem is unbranched, and many of the pinnules are over 12 cm. long. In another specimen, 0·5 m. long, the pinnules average 3·2 cm. in length, but in the middle portion they are subequal and about 3·5 cm. long. The pinnules are straight, rigid, filiform, and pass out almost at

right angles to the axis. They are arranged in six rows around the stem, the members of each row being almost in a plane, so that when seen from above the pinnules are arranged in six subregular groups radiating from a common centre. The pinnules are arranged in interrupted spirals, the six adjoining ones, making one revolution of the axis, being disposed in two half spirals in opposite directions. The members of one half spiral are placed in ascending series, from left to right, and subequidistant; each succeeding pinnule only slightly above its predecessor. The members of the second half spiral are similarly related to one another, but in this case the ascent is made from right to left, and the series is so placed that its lowest member is slightly above the highest of the first series. The two highest and the two lowest pinnules of each half spiral form adjoining longitudinal rows. Of those pinnules disposed in one vertical plane there are about eleven to 3 cm.

The arrangement of the spines near the apex of a pinnule has been figured by Lacaze Duthiers (45, pl. iv. figs. 23–25). They are there relatively long and bent inwards towards the axis, and usually very far apart. Towards the middle of a pinnule (Pl. XII. fig. 20) the spines are disposed in regular spirals, which probably pass from left to right, but a spiral of the opposite direction is almost equally well marked. There are only three longitudinal rows visible from one aspect of a pinnule, and the spines are longer on one side than on the other. The short spines are triangular with a sharp apex; the others are more or less hooked upwards. Towards the base of a branch, and also on the stem, all the spines become reduced to the short triangular type, with a slender apex standing out horizontally. The polyps of this species have been described under the genus. About four or five are arranged to a centimetre on the pinnules.

Habitat.—Mediterranean (Esper, Lacaze Duthiers); Bay of Naples in 54 fathoms (Naples Zool. Stat.); ? Martinique (M.-Edw., Duch.).

Parantipathes? tetrasticha (Pourt.).

Antipathes tetrasticha, Pourtalès, Bull. Mus. Comp. Zoöl., No. 7, 1868, p. 133; Cat. Mus. Comp. Zoöl., pt. iv., 1871, p. 53; Bull. Mus. Comp. Zoöl., 1880, pl. iii. figs. 1 and 30.

Corallum a simple stem, pinnate, branchlets alternate and double, *i.e.*, two starting from the same point at an acute angle, thus forming four rows, two on each side of the stem. In some specimens only a few of the branchlets are double, in others nearly all. Towards the base one of the branchlets of a pair is often abortive.

Sclerenchyma black, nearly smooth, showing very short blunt spines only under a magnifier. There is no succession of swellings on the branchlets as in *Aphanipathes filix*, &c.

The spines are short, blunt, and somewhat triangular, and not very close-set. Three

longitudinal rows are visible from one aspect of a pinnule (*cf.* Pourtalès, **71**, pl. iii. fig. 1).

Polyps small, much elongated; tentacles short and blunt in spirit specimens, arranged as in *Parantipathes larix*, so that the lower side of a branchlet appears fringed with tentacles in pairs, some attention being required in order to distinguish the individual polyps by the position of the mouth. All the polyps are of one size on a pinnule, but generally larger on the main stem and between the pinnules. Total height 7 cm., length of the pinnules 3 to 4 cm. The pinnules of this species are arranged in a similar manner to those of *Aphanipathes alata*.

Pourtalès remarks that [*Antipathes*] *americana*, D. and M., is a pinnate species with a simple stem, but the pinnules dichotomise frequently, which is never the case here.

Habitat.—Off Sand Key, and the Samboes, Florida, in 116, and in 120 to 125 fathoms (Pourtalès).

Parantipathes? fernandezi (Pourt.).

Antipathes Fernandezii, Pourtalès, Cat. Mus. Comp. Zoöl., pt. viii., 1874, p. 47; Bull. Mus. Comp. Zoöl., 1880, pl. iii. fig. 20.

Main stem unknown. Branchlets pinnate, with alternate and rather long pinnules. Densely hirsute, with rather short spines disposed in longitudinal rows. Spines somewhat compressed and hooked upwards near the tip. They are rather longer and more numerous than in *Parantipathes tetrasticha*.

Polyps elongate, with short tentacles, rather crowded on the upper part of the pinnules.

Habitat.—Off Juan Fernandez, in 65 and 220 fathoms (Pourtalès).

Parantipathes? hirta (Gray) (Pl. II. fig. 11; Pl. XI. fig. 1).

Antipathes hirta, Gray, Proc. Zool. Soc. Lond., 1857, p. 293.

"Coral branched, branches divaricated, branchlets from all sides of stem, crowded, and generally bent up toward one surface, elongate, nearly of uniform length, simple, with a few filiform, generally short branches on their base" (Gray, *loc. cit.*).

The British Museum specimen is over 60 cm. high and irregularly branched. The stem shortly above the base divides into three portions, all ultimately directed subvertically. The smaller branches are given off almost at right angles to the axis, but after a time arch upwards and take a subvertical direction. These in turn bear smaller branchlets, many at right angles, but others at an acute angle. Both branches and branchlets are clothed with spirally arranged, short, slender pinnules, which may be simple, but more usually bear very short secondary processes at right angles and generally on one side

only. The pinnules are usually from 0·6 to 1·2 cm. long, but a few are longer. As in other forms, a pinnule, by increase in importance and the development of a secondary series of pinnules on all sides, becomes one of the smaller branchlets. All the lower pinnules (2 cm. long) on the more important branchlets bear four to six secondary pinnules 0·3 to 1 cm., all springing from one side. Some of these bear two to four short processes also all on one side (the inner); most are simple, but one here and there may be forked (Pl. II. fig. 11). This peculiar subdivision of the pinnules is not met with in any other species known to me, but a more rudimentary condition of the same type of branching is seen in *Aphanipathes? barbadensis*, n. sp.

The spines are of medium length, subcylindrical, and hooked upwards. They are arranged in steep dextrorse spirals and also in longitudinal rows, five of which may be counted from one aspect of a pinnule. The members of a row are from one to two lengths apart, and the spines in some rows are longer and more hooked than those in others, recalling the condition in *Parantipathes larix* (Pl. XI. fig. 1).

Habitat.—West Indies (Scrivener), Brit. Mus.

Parantipathes? columnaris (Duch.).

Arachnopathes columnaris, Duchassaing, Rev. d. Zooph. et d. Spongiaires d. Antilles, 1870, p. 23.

Antipathes columnaris, Pourtalès, Cat. Mus. Comp. Zoöl., pt. viii., 1874, p. 46, pl. ix. fig. 8; Bull Mus. Comp. Zoöl., 1878, p. 209; *ibid*, 1880, p. 117, pl. iii. fig. 3.

"Ramis ramulisque inter se crassitie æqualibus, centralibus inter se crebre anastomosantibus, ac indè columnam centralem reticulatim æmulantibus; ramulis exterioribus e columna nascentibus; pinnulis brevibus, tenue muricatis, nec nodoso-geniculatis" (Duch., *loc. cit.*).

Pourtalès, who has found this species abundant amongst the collections of the "Blake" Expeditions, gives the following additional particulars:—

The stem is simple, the branchlets in verticils close together, themselves verticillate and sometimes biverticillate, coalescing occasionally. The verticillate branchlets give this species a bottle-brush form. The spines are very small, triangular and blunt, somewhat longer at the tip of the pinnules (*cf.* Pourt., **71**, pl. iii. fig. 3). The central reticulated column is hollow and the habitation of an Annelid, which seems to compel the corallum to form an abnormal growth of that shape. Height of the corallum 9 to 10 cm.

The polyps, according to the observations of Pourtalès, are small and difficult to see; they are of the sessile type, the tentacles appearing only as small knobs disposed in three pairs on the branchlets, but spread out on the stem. The polyps are rather abundant in the network forming the tube for the parasitic worm. Two of the specimens obtained were destitute of the parasite, and of the tube produced by it; their branchlets are more spiny, but the general shape is the same.

Pourtalès gives a good figure of this species (**58**, pl. ix. fig. 8), from which it is seen that the branches are slender, and bear verticillate or biverticillate pinnules in a most characteristic manner.

Habitat.—Off Guadeloupe, 35 to 50 fathoms (Duch.). Occurring at sixteen stations in depths from 73 to 861 fathoms, off Guadeloupe, Martinique, Dominica, Virgin Gorda, St. Lucia, St. Vincent, the Grenadines, and Barbadoes (Pourt.).

Subfamily Schizopathinæ, Brook.

Antipathidæ possessing dimorphic zooids. The dimorphism consists of a differentiation of the typical Antipathid zooid into three zooids, of which an anterior and posterior (as arranged on the sclerobasic axis) are reproductive, and may be termed *gonozooids*. The central one of each group is nutritive, and may be conveniently named the *gastrozooid*.

The gastrozooid has the usual arrangement of mesenteries found in the Antipathinæ; the gonozooids have only one mesentery each, situated in the transverse axis. This represents the distal portion of the much elongated transverse mesenteries in some Antipathinæ, *e.g.*, *Parantipathes*. Each zooid possesses two tentacles, so that each group of three has the proper number of tentacles characteristic of the Antipathidæ. The zooids may be closely packed, or situated at some distance from one another.

The species at present known, which are referable to this subfamily, have nearly all been obtained at great depths, and in all, the spines on the axis are of the triangular or subtriangular type.

Synopsis of Genera.

A. Corallum consisting of a simple stem, bearing elongate, simple, and usually lateral branches; spines short and conical, extending at right angles to the axis.
   - α. Base free, flattened and tapering, hooked up at the extremity; zooids crowded; stomodæum elongated in the sagittal axis, ... *Schizopathes*, n. gen.
   - β. Base dilated and adherent; zooids always isolated, ... *Bathypathes*, n. gen.

B. Corallum much branched; spines longer and hooked upwards.
   - α. Corallum consisting of an erect stem with strong branches at right angles, bearing six rows of pinnules in two opposite half spirals; zooids somewhat isolated; mesoglœa thin; stomodæum elongated in the transverse axis, . . *Taxipathes*, n. gen.
   - β. Corallum in plumose branches, with numerous short circumaxial pinnules; zooids crowded; stomodæum very long and irregular; mesoglœa thick; only six mesenteries present in the oral prominence, ... *Cladopathes*, n. gen.

Genus *Schizopathes*, n. gen.

The dimorphic zooids are always close together in normal portions of the colony, and there is no isolation of the zooids into triplets. The degenerate zooids near the base

of a branch may, however, in certain species become isolated. The stomodæum is elongated in the sagittal axis, and the mouth opens at the apex of a prominent oral cylinder or cone. The nematocysts are unusually large. There are ten mesenteries in the gastrozooid, and only one in each of the gonozooids.

The corallum is not attached by a dilated base to some foreign body, but the base is free, flattened, and tapering, and is more or less hooked up at the extremity. In the species at present known the stem is simple, and bears only two series of elongate and simple branches.

Schizopathes crassa, n. sp. (Pl. VIII.).

Branched portion of the corallum flattened, subtriangular; branches lateral, alternate, closely set; the lower ones long, the others gradually becoming shorter towards the apex of the stem. Spines short, conical, distant, arranged in longitudinal rows.

The single specimen on which this species is based is the finest example of the Schizopathinæ contained in the Challenger Collection. The stem is 57 cm. long, gracefully but gently flexuose, with a peculiar flattened sickle-like base replacing the rounded horny disc by which the Antipathinæ are attached to stones and other objects. In this case the species is probably fixed by the base being embedded in the mud constituting the bottom deposit in the area in which it occurs. The specimen is 53 cm. high, and measures 53 cm. also across the lower branches. The stem is simple, much flattened below, but gradually becoming cylindrical and slightly tapering above the lower branches. Diameter between the basal branches $1{\cdot}3 \times 2$ mm. The largest branches have a diameter of 1 mm. at the base.

The basal 3·3 cm. of the stem is devoid of branches and forms a sickle-shaped stalk, by which the corallum has probably been fixed. This stalk is much flattened and relatively broad in the middle portion, tapering off again below to a small hooked point. Its greatest breadth (3 mm.) is in a plane at right angles to that in which the branches extend. This portion of the stem is smooth, excepting near the anterior surface, where there are one or two rows of short spines on each side. The apical 2·5 cm. of the stem is also without branches.

In the intermediate portion there are seventy branches in all, which are lateral and regularly alternate, excepting in one place near the apex of the stem, where three branches are given off successively on the left side. The branches are subequidistant, there being about twenty branches to each 12 cm. of the stem. The lowest branches are 30 cm. long, and after ascending for some distance at an acute angle with the stem become gently recurved in their distal halves. The middle branches are about 22·5 cm. long and nearly straight; the terminal ones 2·7 and 3·6 cm. long, with their distal portions incurved, so as to be almost parallel with the stem. All form an acute angle with the axis.

The spines are arranged in longitudinal rows, five of which are visible from one aspect. The number of spines in each row varies considerably; they are, however, usually distant, but here and there two spines may be quite close together. The spines form short laterally compressed cones with a sharp apex; they are placed at right angles to the axis, and are usually about as high as broad (Pl. VIII. fig. 5).

In the terminal portion of each branch, the sclerenchyma is thin and membranous, the spines are very far apart, and the whole axis for several inches collapses when dry.

The whole corallum, with the exception of the basal portion of the stalk, is densely covered with zooids. There is no interval between adjoining zooids either as regards the members of a group (triplet) or the adjacent members of successive groups. There are usually six zooids to a centimetre on the branches, but in parts where the gonozooids become much distended with the reproductive elements they may be a little more distant (five to a centimetre). Height of zooid, excluding tentacles, about 2 mm.; breadth across base of tentacles 3 mm.; length of tentacles 4 to 7 mm. These measurements are only approximate, as in spirit specimens the amount of contraction varies a little in different portions of the colony. There appears, however, no difference in the size of the zooids which may not be attributed to unequal contraction or to a variable development of the reproductive elements (Pl. VIII. fig. 3).

The gonozooids seen from above are oval in outline, the greatest diameter, *i.e.*, in the sagittal axis, being 2·5 to 3 mm. Each gonozooid has a more or less well-marked depression in the transverse axis corresponding to the position of the mesentery.

The gastrozooids are similar in outline to the gonozooids. The mouth, which is usually rounded in outline, is situated on a cylindrical prominence placed between the pair of tentacles. Ova were found in various stages of development in all the gonozooids examined microscopically, so that it seems probable that the species is dicœcious.

Habitat.—Station 323; February 28, 1876; lat. 35° 39′ S., long. 50° 47′ W., off Monte Video; depth, 1900 fathoms; bottom, blue mud.

Schizopathes affinis, n. sp. (Pl. IX. figs. 1–6).

Branched portion of the corallum flattened, triangular; branches lateral, alternate; the lower ones very long, the others rapidly becoming shorter towards the apex of the stem. Spines crowded, conical, and very short, arranged in imperfect verticils or sometimes with a slight indication of a spiral arrangement.

The base is free and flattened as in *Schizopathes crassa*, but the extremity is more hooked. The middle of each flattened surface bears three or four longitudinal furrows bordered by rows of short sharp serrations (Pl. IX. figs. 5, 6). The total length of the stem is about 31 cm., the length from the lowest branch to the point of the hooked base about 12 cm. The stem is somewhat flattened to near its apex; the lower portion is black,

but the upper third is reddish brown, becoming fulvous at the tip. The portion above the hook is simple, nearly straight, and scarcely tapering, having a diameter of 1 × 0·4 mm. near the middle. The branches are regularly alternate; the lower ones are black in the basal portion, but all are membranous and fulvous near the apex. One specimen bears forty-eight branches, all of them being simple and arising at an acute angle, which is rather narrow in the upper portion of the corallum, but much wider below. The two series of branches are alternate, and extend almost in one plane. The lower ones are very long, and are often gently curved upwards towards the apex. The branches rapidly become shorter from the lower ones towards the apex of the stem. The basal branches are 20 cm. long, those about one-third higher are 11 cm., those two-thirds higher 5·7 cm., whilst the apical ones are only 2·5 cm. long. The lower branches are rather farther apart than those above. There are ten branches to 5 cm. below and fifteen in the same distance near the apex.

The spines are very short and conical, with a sharp apex, but all are compressed laterally. They are of the same type as those of *Schizopathes crassa*, but are more numerous. An indication of an irregular dextrorse spiral arrangement is sometimes observable, but more usually three, four, or five spines are arranged at the same level on a branch, forming incomplete verticils. They are also arranged in longitudinal rows, five of which may be counted from one aspect, but the spines are more numerous in some rows than in others (Pl. IX. fig. 4).

The zooids are similar to those of *Schizopathes crassa*, but smaller, and the prominence on which the mouth opens is neither so long nor so cylindrical. The five specimens referred to this species show the zooids in various stages of degeneration. In two of them they are close together from the apex to near the base of the branches—a condition similar to that in *Schizopathes crassa*, and one which I regard as normal. In two others the zooids are normal and close together on the terminal 3 to 8 cm. of a branch, but below that become separated from one another by a considerable interval, as in *Bathypathes*. It should, however, be noted that in the species under consideration the isolated zooids are degenerate; the body of the zooid becomes gradually more and more reduced, until near the base of a branch it is entirely obliterated, and two slender tentacles projecting from the cœnenchyma are all that remain to indicate its position. It is one of these specimens which has been chosen for illustration (Pl. IX. fig. 1). The fifth specimen has the polyps normally distributed on the apical portions of the branches, but those below are almost entirely obliterated. This species is distinguished at a glance from *Schizopathes crassa*, on account of the different relative development of its branches and the greater degree of curvature in the hooked base, which is similar in all the specimens.

Habitat.—Station 195; October 3, 1874; lat. 4° 21′ S., long. 129° 7′ E., off Banda Islands; depth, 1425 fathoms; bottom, blue mud. Four specimens.

Station 218; March 1, 1875; lat. 2° 33′ S., long. 144° 4′ E., west of Admiralty Islands; depth, 1070 fathoms; bottom, blue mud. One specimen.

Schizopathes conferta, n. sp. (Pl. VI. figs. 1–3).

Branched portion of the corallum not flattened, branches antero-lateral, very crowded, in two rows enclosing a narrow acute angle. Spines numerous, irregular, conical, arranged in imperfect longitudinal rows.

This is a large strong species, having only two rows of simple branches, as in other species of the genus, but in this case they do not extend in one plane. The type specimen is incomplete, and consists of only a middle piece of the stem about 17·5 cm. in length. The stem is distinctly tapering, and has a diameter of 3·5 mm. below and 2 mm. above; its surface is rough and black, but in many places the spines are completely covered by a layer of a glossy black substance resembling pitch. The branches are very long and rigid, and are disposed in two subalternate rows, which spring from a point a little on each side of the anterior surface of the stem. The two rows of branches enclose a narrow acute angle near their origin, but are curved outwards and then inwards, so that the distal portions of the two series often cross. The branches are very numerous; there are sixty-four in all, which are somewhat regularly disposed, three or four to a centimetre. The unbroken branches are 25 to 30 cm. long, and taper very gradually. The spines are numerous, short, and conical, with a compressed elongate base, forming longitudinal ridges on the surface of the sclerenchyma. Their distribution is most variable; sometimes they have an imperfect spiral arrangement, at others they are disposed in longitudinal rows, whilst in other portions again there is the greatest irregularity. On the lower portions of a branch many of the spines have a bifid apex, whilst the majority lose their sharp points and give a papillose roughness to the stem and branches. The distal extremity of each branch is semimembranous and is clothed with soft spines, which are not so numerous as on the lower and firmer portion.

The zooids are similar to those of *Schizopathes crassa*, and the dimorphic individuals are close together in all parts where they are preserved. About five are distributed to each centimetre; the oral aperture opens at the top of a prominent cylindrical projection of the peristome, as in the type species.

The base of this species is not preserved, so that I am unable to say whether it agrees with other species of the genus in having a free tapering and hooked base. So far as we know at present, *Schizopathes crassa* and *Schizopathes affinis* are the only species of Antipatharia in which the corallum is not permanently fixed to some foreign object by a dilated base.

Habitat.—Station 145A; December 27, 1873; lat. 46° 41′ S., long. 38° 10′ E., off Prince Edward Island; depth, 310 fathoms; bottom, volcanic sand.

Genus *Bathypathes*, n. gen.

The dimorphic zooids in this genus are always separated from one another by a considerable interval, even at the apex of a branch, and are united together by median stolon-like outgrowths of their cœlentera. The mouth opens on the general surface of the peristome, or is situated on the apex of a short conical or cylindrical projection of it, as in other Schizopathinæ. The corallum is pinnate and attached to a stone or some other foreign object by a dilated base. The zooids have a similar structure to those of *Schizopathes*, but an elongation of the stomodæum in the sagittal axis is never marked. Usually its greatest length corresponds with the transverse axis of the gastrozooid. The gonozooids contain very few ova, which are large, and each is enclosed in a special chamber.

Bathypathes patula, n. sp. (Pl. V. figs. 1–4).

The stem in the type specimen is 19 cm. long, nearly straight, unbranched, with a rounded dilation at the base, which is attached to a small stone. The axis is slender, and a little thicker near the middle than at the base. The whole, in one well-preserved specimen, is covered with a delicate cœnenchyma to within 18 mm. of the point of attachment.

The branches are lateral, simple, elongate, slender, and are arranged in pairs nearly but not quite opposite each other. The longest measures 7·5 cm. Opposite branches are not in the same plane, but inclined to each other at an obtuse angle, with their distal portions recurved. The polyps are situated on that face (anterior) which borders the obtuse angle. There are two specimens of this species in the Challenger Collection, one with nine pairs of branches and the other eleven. The middle pair of branches are longer than the others. The first pair is given off about half-way up the stem. The pairs are all nearly equidistant, and about 9 mm. apart.

The sclerenchyma is brownish black, that of the branches getting paler towards the tip, where the colour is yellowish brown. The branches have a small, central, longitudinal canal, which widens out towards the tip, where the sclerenchyma is thin and membranous. In this portion the surface is sinuous, and spines in process of formation are indicated by short, thickened, longitudinal ridges. Below, the spines are short and triangular, arranged in longitudinal rows, five of which are visible from one aspect. The members of a row are from four to five lengths apart. The spines are also disposed in irregular dextrorse spirals, which are more open than in any other species of the genus.

The zooids are subequidistant, about 3 mm. apart. They appear as conical, or subtriangular, elevations, bearing two lateral and opposite tentacles as long as the whole zooid. The oral surface is thickened and rounded. The mouth in the

gastrozooids is slit-like, with its long axis transverse. In the gonozooids there is a swelling at the base of each tentacle, and between the two a longitudinal depression.

Two or three young specimens, which probably belong to this species, were obtained at Station 195. The stem is very slender, like a bristle, about 11 cm. long, and bears near the apex three or four subopposite pairs of simple branches from the antero-lateral margin, which are arched forwards and then recurved. The lower ones are 4 cm. long, the others shorter, the terminal pair being nearly 1 cm. long.

Var. *plenispina*, nov. (Pl. V. fig. 5).

A single specimen from Station 218, 1070 fathoms, differs from the type in minor points, but chiefly in the number and relative size of the spines. The specimen, which is 12 cm. long, is attached to a small stone. The stem is very slender, and only bears branches on the lower part of the upper half of its length, where the stem is slightly thicker. The lower 6·3 cm. of the stem does not bear branches. The succeeding 14 mm. gives off three pairs of branches, which are nearly but not quite opposite. The lowest branch leaves the stem on the left side, then, only 0·8 mm. above it, one passes off on the right; next, after an interval of nearly 6 mm., another subopposite pair is given off, and finally the upper pair at a similar distance from the middle pair, but this time it is the branch on the right side which leaves the stem first. The inclination of the three pairs of branches also differs. The upper pair includes a wide obtuse angle, the middle pair an angle only little exceeding 90°, while the lower pair includes an acute angle. In general appearance the specimen closely resembles the type of *Bathypathes patula*. The specimen is nearly void of polyps, but from the fragments present it seems very probable that they closely resemble those of the type.

The spines are, however, much more numerous and rather stronger, with a broader base than in the type specimens. They are disposed in irregular and rather close dextrorse spirals and also in longitudinal rows, four of which may be seen from one aspect of a branch. The members of a row are here only two to three lengths apart (Pl. V. fig. 5).

Habitat.—Type. Station 244; June 28, 1875; lat. 35° 22′ N., long. 169° 53′ E.; depth, 2900 fathoms; bottom, red clay. One specimen.

Station 246; July 2, 1875; lat. 36° 10′ N., long. 178° 0′ E.; depth, 2050 fathoms; bottom, Globigerina ooze. One specimen.

Young.—Station 195; October 3, 1874; lat. 4° 21′ S., long. 129° 7′ E.; depth, 1425 fathoms; bottom, blue mud. Two specimens.

Var. *plenispina.*—Station 218; March 1, 1875; lat. 2° 33′ S., long. 144° 4′ E.; depth, 1070 fathoms; bottom, blue mud. One specimen.

Bathypathes alternata, n. sp. (Pl. IX. figs. 7–10).

Stem slender, straight or slightly flexuose, bearing alternate lateral branches, the lower ones longer and, in their distal portions, gracefully incurved, the others gradually becoming shorter towards the apex. Spines short, thorn-like, with a broad base, not in a distinct spiral, in some cases appearing as if disposed in irregular verticils.

A single specimen of this species from Station 246 measures 18·5 cm. in length, and the stem near the base has a diameter of 0·6 mm. In general appearance this form approaches *Bathypathes patula*, but is more slender; the branches are regularly alternate, instead of being subopposite, and the spines are more numerous and without regular arrangement (Pl. IX. figs. 7–10).

The stem has a dilation at the base, by which the specimen is attached to a small stone. It is nearly straight, but has a slight curve to the right in the lower portion. The basal 7·5 cm. of the stem is without branches. In the succeeding 10·2 cm. thirteen branches are given off on the right side, and twelve on the left. These are lateral, and pass out at a moderate acute angle in the lower portion, but above, the angle is not so wide. At first the branches, which are regularly disposed, are about 4 mm. apart, in the middle portion they are a little more crowded, but towards the apex the interval is again increased. The lowest branches are 10·5 cm. long, and in their distal half are gracefully curved upwards, so as to approach the stem. The others have a similar arrangement, but become shorter and shorter towards the apex, until the final ones are only 2 to 2·5 cm. long. The diminution in length is gradual. The branches are nearly in one plane, and the breadth of the specimen across the lower branches is 14 to 15 cm.

The zooids, which are only preserved on a few of the branches, are of the same type as in *Bathypathes patula*, but smaller. The gastro- and gonozooids are of equal size (excepting in the reproductive season ?), and are separated by a space equal to half the length of the zooids. In the basal portions of the branches the zooids are more distant, as is frequently the case in other species. They average 1·4 mm. long and 0·65 mm. broad. The mouth in the gastrozooids is elongated in a direction transverse to the axis of the branch.

The sclerenchyma is black in the lower portion of the stem and branches, and nearly smooth, becoming fulvous and more distinctly spinose above.

The spines are in seven or eight irregular longitudinal rows, and are thorn-shaped, flattened, and have an elongated base. They are not disposed in regular spirals, and, indeed, in some parts appear as if in irregular verticils. The spines are disposed in longitudinal rows, four of which may be seen from one aspect. They are more numerous in some rows than in others, and the members of a row are from two to five lengths apart.

Habitat.—Station 246; July 2, 1875; lat. 36° 10′ N., long. 178° 0′ E.; depth, 2050 fathoms; bottom, Globigerina ooze. One specimen.

Bathypathes lyra, n. sp. (Pl. VI. figs. 4–6).

A small lyrate species having usually alternate lateral branches, the lower ones being very long and curved upwards towards the apex, and in addition having a row of short spinous branches on the anterior surface standing out at right angles to the stem and lateral branches.

Stem slender, straight, tapering, of a rich red-brown colour near the base, gradually becoming fulvous towards the apex. In one specimen the stem is 11·5 cm. long, and has a dilation at the base by which it is attached to a small stone. The main branches are lateral and alternate, excepting near the base, where two are opposite. They are simple, elongate, and filiform, placed at first almost at right angles to the stem, but above, the angle becomes gradually reduced. The lowest branches, a pair, are given off about 1·3 cm. from the base; the others arise alternately on the right and left sides, and are nearly in the same plane. Most of the main branches are ultimately incurved and reach a point on a level with the tip of the stem. The lower ones are 11·5 cm. in length, the others becoming shorter towards the apex, the youngest being only 2·4 cm. long. In this specimen there are eighteen lateral branches in all, sixteen of which are alternate and the two basal ones opposite. In addition to the lateral branches there is a series of short, simple, setose branchlets on the anterior surface of the stem, passing out horizontally in a plane perpendicular to that occupied by the stem and lateral branches. These are confined to that portion of the stem bearing lateral branches. In the lower portion they are about 6 mm. apart, becoming more closely crowded towards the middle of the stem. Their average length is 6 mm.

The zooids are regular in size and almost equidistant from base to apex of each branch, being usually about 3 mm. apart. They are similar to those of *Bathypathes patula*, but are smaller, and in spirit specimens have more flattened leaf-like tentacles.

Another and smaller specimen from a different locality agrees well with that already described, even having the first two lateral branches opposite instead of alternate, a feature which otherwise might have been considered accidental. In this specimen, which is 6·5 cm. long, the soft parts are not preserved, and the dilated base of attachment is broken away. The anterior short spinous branchlets have the same character and distribution.

The spines are very short and conical, with an elongate base, and show no regular arrangement. Compared with those of *Bathypathes alternata* the spines are smaller, more numerous, and are disposed with greater irregularity. Four or five longitudinal rows are visible from one aspect, the members of a row being from one to five lengths apart. In places where the spines are less crowded an irregular spiral arrangement may be made out.

Habitat.—Station 246; July 2, 1875; lat. 36° 10′ N., long. 178° 0′ E.; depth, 2050 fathoms; bottom, Globigerina ooze. One specimen.

Station 181; August 25, 1874; lat. 13° 50′ S., long. 151° 49′ E.; depth, 2440 fathoms; bottom, red clay. One specimen.

Bathypathes tenuis, n. sp. (Pl. VI. figs. 7–10).

Corallum very slender; the stem is no thicker than a bristle, and bears near its apex two or three hair-like alternate branches, one or more of which may bear a short secondary branch from its upper surface.

The stem is about 11 cm. long, very slender, like young forms of *Bathypathes patula*, and bears two or three alternate or subalternate branches near the apex at an acute angle, one or more of which may be 3·5 cm. long. The longer ones sometimes bear a single branchlet almost at right angles and directed upwards (Pl. VI. fig. 7). The polyps are imperfectly preserved but are always isolated, and have all the characters of those of the genus *Bathypathes*. The spines on the branches (Pl. VI. fig. 9) are short, triangular, and scattered, and have no definite arrangement. Near the base of the stem (Pl. VI. fig. 10) they are arranged in subregular rows, three of which may be observed from one aspect. The members of some rows are more numerous than those of others; they are from two to five lengths apart.

This species comes very near to the young forms of *Bathypathes patula*, but bears fewer branches, and these are not so much arched forwards. I have considered it distinct on account of the fact that the branches sometimes bear a single branchlet, a feature which has not been observed in any other species of the genus. The arrangement of spines also differs from that of other species, but comes nearest to that of *Bathypathes alternata*. The spines are, however, smaller and more distant than in that species.

Habitat.—Station 160; March 13, 1874; lat. 42° 42′ S., long. 134° 10′ E.; depth, 2600 fathoms; bottom, red clay. Two specimens and a number of fragments.

Genus *Taxipathes*, n. gen.

Dimorphic zooids small and rather close together. In the gastrozooid the stomodæum is elongated in the transverse axis, and the mesoglœa is thin and structureless. There are ten mesenteries in the gastrozooid, those in the transverse axis being continuous below with those of the gonozooids. The ova are large, but not enclosed in special chambers. The stem is branched, and each branch bears six rows of slender rigid pinnules arranged in half spirals as in *Parantipathes larix*. The form of the base is not known. The single species referred to this genus presents a curious medley of characters. Perhaps it most closely resembles *Parantipathes larix*, but the pinnules are much shorter and the zooids are dimorphic, each with two tentacles. The zooids

have a general resemblance to those of *Schizopathes*, but differ in the direction in which the stomodæum is elongated, in the structure of the ovaries, as well as in other points. The corallum also lacks the simplicity of *Schizopathes* and *Bathypathes*. The spines are of the same type as those of *Cladopathes*, but the two genera differ considerably in the structure of their zooids.

Taxipathes recta, n. sp. (Pl. VII.).

Stem straight, erect, bearing strong lateral branches, usually at right angles, which may in turn bear branchlets on their anterior or posterior surfaces. The stem, main branches, and branchlets are clothed with six rows of short simple pinnules at right angles, arranged in interrupted spirals as in *Parantipathes larix*. Spines comparatively distant, conical, and somewhat hooked upwards; disposed in longitudinal series. The type specimen consists of the upper 26 cm. of a stem, together with the branches or pinnules which it bears. The base is not preserved, but, judging from the thickness of the stem, it is probably not free and sickle-shaped as in *Schizopathes*.

The stem is round, erect, and distinctly tapering; it has a diameter of 3 mm. below, and about 0·5 mm. near the apex. It bears a number of sublateral branches at irregular intervals, and not in a plane, some of which are strong and elongate. Most of them form a very wide angle with the stem—almost a right angle. Probably this feature was more marked in the living specimen than it appears in the spirit preparation. When first taken from the jar in which the specimen had been preserved, the upper portion of the stem was bent to one side, and the strong branch near the base of the specimen was arched upwards (in the manner represented in Pl. VII. fig. 1), but after being placed in a larger jar for some days the stem lost its curvature, and the strong branch referred to assumed a subhorizontal position, evidently showing the curvature to be due to pressure. None of the stronger branches are complete. Two of them, one near the base of the specimen, and the other 12·5 cm. higher up and on the opposite side, have evidently been very long, and have a diameter of 1·7 mm.; a number of others are over 1 mm. in diameter. The branches vary from 2·5 to 14 cm. in length, but two or three have been considerably longer. Some of them bear one or two secondary branches, from 1·5 to 9 cm. long. These usually project either vertically downwards, upwards, or have an oblique subhorizontal course. The stem, as well as the primary and secondary branches, are clothed with six rows of relatively short, slender, and rigid pinnules, the arrangement of which will be understood by a reference to Pl. VII. figs. 4, 5. Three of the rows are arranged in a sinistrorse half spiral; the other three are arranged in a dextrorse half spiral in such a manner that the highest members of each half spiral, as also the lowest, form adjoining rows. The arrangement is very similar to that which obtains in *Parantipathes larix*, excepting that in this case the rows are not equidistant, but an

obtuse angle is included between adjoining rows of opposite spirals (Pl. VII. fig. 4). The pinnules are very variable in length, but 2·2 cm. appears to be the maximum. Those in some rows are frequently longer than those in others, and it appears probable that in some cases the pinnules are longer on one side of a branch than on the other, but so many of them are broken in the type specimen that it is difficult to decide. There are usually six or seven half spirals (eighteen to twenty-one pinnules) to a centimetre. This species shows, perhaps, more clearly than any other the gradual transition from simple pinnules to the strongest branches borne by the stem. When one bears in mind that the main branches have all been derived from the pinnules of the stem, and the secondary ones from the pinnules borne by these in turn, it is easy to understand how the primary and secondary branches come to have such a varied direction. The spines are thorn-like in outline, and slightly hooked upwards. A spiral arrangement is not noticeable, but the spines are arranged in longitudinal rows, four of which may be seen from one aspect of a pinnule. The members of a row are placed at somewhat irregular intervals, from one to two and a half lengths apart. The spines in this genus, and in *Cladopathes*, differ from those of other Schizopathinæ in being longer and bent upwards, instead of extending at right angles to the axis.

The polyps are very small, with short tentacles, and are confined to one aspect of a pinnule. There are usually about eight to a centimetre, with a slight interval between each. They appear to be closer together on some pinnules than on others.

Habitat.—Station 344; April 3, 1876; lat. 7° 54′ 20″ S., long. 14° 28′ 20″ W., off Ascension; depth, 420 fathoms; bottom, volcanic sand. One specimen.

Genus *Cladopathes*, n. gen.

Dimorphic zooids much crowded and frequently incompletely separated from one another. The mouth is situated at the summit of a thick cylindrical projection of the peristome. The stomodæum is very long, and reaches nearly to the periaxial sheath of the sclerenchyma. It is much folded, and the longest diameter does not correspond with the sagittal axis. The mesoglœa is very thick, and contains numerous stellate or rounded cells as in certain Actiniaria. The corallum is much branched, and the branches bear numerous short radiating pinnules. The spines of *Cladopathes plumosa* are larger than those of any other member of the subfamily, and are somewhat bent upwards.

Cladopathes plumosa, n. sp. (Pl. II. figs. 1–4).

Corallum in long plumose branches, which are more or less subdivided, each branchlet bearing a large number of short radiating pinnules. Spines relatively large and triangular, similar to the usual type in the genus *Antipathella*.

This species, of which two specimens were obtained off Prince Edward Island, is a

large shrub-like form so densely clothed with polyps that it is only possible to get a clear idea of the mode of branching from parts divested of their fleshy covering.

The plumose branches are from 15 to 31 cm. long, slightly tapering, and bent several times in a zig-zag fashion. Sometimes the original course of the branch before a bend is continued as a short tapering process at the outer angle; at others this process is stronger and gives rise just below its apex to an important lateral branch bearing the usual arrangement of branchlets and pinnules. The whole of the branches are clothed with pinnules arranged in three or four series, showing a subspiral arrangement. In cases where there are three rows of pinnules, two generally arise from the antero-lateral surfaces, and the third from the posterior surface. At other times two may be lateral, a third anterior, and a fourth posterior. Truly lateral pinnules are, however, of comparatively rare occurrence. The pinnules are usually short, and arranged about ten or twelve to a centimetre. The most frequent type is a short forked pinnule from 0·4 to 1 cm. in length. Sometimes the superior arm of the fork is much longer than the other, in which case the length may reach 2 cm. Simple pinnules also occur frequently, and are from 1 to 2·5 cm. long; these are more numerous and usually of greater length in the newer portions of the corallum. Finally, the pinnules may become stronger and then bear three or four rows of short secondary pinnules similar to those on the larger branches, but smaller. In this way, by the increase in importance of certain pinnules, the branchlets are formed. These are mostly sublateral or posterior, and vary from 2·5 to 6 cm. in length. They are placed at irregular intervals, and it is to be noted that only rarely does an anterior pinnule become increased in importance so as to form a branchlet, and when this occurs, the branchlet becomes bent so as to extend sublaterally.

The zooids are usually much crowded and do not appear to be so isolated as in other Schizopathinæ. Six or more occur to a centimetre and the elongation of the mouth is usually situated obliquely (Pl. II. fig. 2). The interzooidal areas are often filled with ribbon-like mesenterial filaments. The fact that the gastrozooids only possess six mesenteries separates this genus from all other known Antipathidæ.

The sclerenchyma is black, polished, and almost smooth in the older and thicker portions of the corallum; there is the usual gradation in colour through dark brown in the branchlets to a bright golden brown in the younger pinnules. The spines are relatively large, subtriangular, with usually a concave upper, and a convex lower, margin. They are somewhat irregular in shape, and the base is often very broad and extends for some distance on each side of the spine as a longitudinal ridge, as is frequently the case in the genus *Antipathella*. They are arranged in irregular dextrorse spirals and also in longitudinal rows, five of which may be counted from one aspect of a pinnule. The members of a row are somewhat irregularly placed, from one and a half to three and a half lengths apart.

Habitat.—Station 145A; December 27, 1873; lat. 46° 41′ S., long. 38° 10′ E., off Prince Edward Island; depth, 310 fathoms; bottom, volcanic sand.

Family Dendrobrachiidæ, Brook.

Genus *Dendrobrachia*, n. gen.

The sclerenchyma ultimately consists of a rounded spinose axis, but is never hollow and tubular as in the Antipathidæ. Towards the apex of a branch it consists of five to seven plate-like portions radiating from a short central rod. The free margin of each plate is dentate. The angle between adjoining plates gradually becomes filled up by a deposition of new layers of sclerenchyma, until in transverse section the outline is almost circular (*cf.* Pl. X. figs. 6, 7, and 8).

The polyps are usually remote, and often arranged in subopposite pairs, the base of each polyp extending over half the axis. The polyps do not stand out at right angles to the axis as in Antipathidæ, but form an acute angle with it.

The tentacles, the number of which is uncertain, are pinnate, having a central stem and lateral relatively elongate branches.

Owing to the imperfect preservation of the type specimen, a satisfactory examination of the structure of the polyps has been found impossible.

Dendrobrachia fallax, n. sp. (Pl. X. figs. 1–8).

The two specimens of this interesting species are about 24 cm. high, but the basal portions of the corallum are not preserved. The stem is nearly round below, has a diameter of 3 mm., and is distinctly tapering. It has an irregular course, gives off a number of branches at irregular intervals, rarely opposite. These again bear smaller lateral and subalternate branchlets at variable intervals, rarely under one centimetre apart on the same side, but in several places the branchlets are subopposite. The ultimate branchlets are from 1 to 5 cm. long. The whole growth is lax and paniculate, and the upper portion of the corallum is quite flaccid. Figs. 6, 7, and 8 on Pl. X. represent transverse sections of the sclerenchyma at three different points of a branch. Fig. 6 is taken from a section near the apex, fig. 7 near the middle, and fig. 8 from near the base of the branch.

The sclerenchyma is deposited in thin lamellæ as in other Antipatharia, but there is no central lumen around which the horny layers are secreted. The longitudinal ridges (Pl. X. fig. 5) have a dentate or spinose margin, but the spines show the greatest irregularity both as regards size and shape. As the intervals between the ridges come to be filled up with sclerenchyma new rows of spines are formed, until ultimately it would be impossible to distinguish the sclerobasic axis externally from that of Antipathidæ. In the older portions of the axis the original outline of the radiating plates appears to be lost, but the centre is occupied by an irregular mass of less dense tissue.

Unfortunately the polyps are very badly preserved, so that I have been unable to obtain much information from a study of sections. They are distributed in two rows on opposite sides of a branch; sometimes they are arranged alternately one length or more apart, at others they are subopposite. It appears probable that there must be some collection of circular muscular fibres representing a sphincter (Rötteken's) muscle, as the tentacles may be completely covered by the margin of the body-wall when in a state of contraction. The tentacles are thick fleshy processes, having a length equal to the height of a polyp, and bear eight or ten digitiform branches of variable length (Pl. X. figs. 3, 4). The number of tentacles is uncertain, but I think it probable that there are only six. I am also at present unable to give any definite information as to the number and arrangement of the mesenteries.

Habitat.—Station 343; March 27, 1876; lat. 8° 3′ S., long. 14° 27′ W., off Ascension; depth, 425 fathoms; bottom, volcanic sand.

Species incertæ sedis.

Nearly all the forms included in this section are probably good species, but it is at present impossible to assign them a definite generic position owing to the want of information regarding the structure of their polyps. In order to distinguish the generic name *Antipathes*, in its restricted sense, from the unmodified genus which practically includes the whole of the Antipathidæ, the word when used in the latter sense has been included within square brackets.

[*Antipathes*] *corticata*, Lamk.

Antipathes corticata, Lamarck, Hist. nat. anim. sans vert., t. ii. p. 306; Dana, Zooph., p. 583.
Hyalopathes corticata, Milne-Edwards, Coralliaires, t. i. p. 324; Haeckel, Arabische Korallen, pl. i. fig. 6.

"A. caule parce ramoso, corticato, spinis numerosis echinato, cortice poris nullis" (Lamk., *op. cit.*).

Haeckel, in his Arabische Korallen, has given us a figure of a living colony of this species, by which it is seen that the polyps have the tentacles arranged in a radiate manner, the individuals being distributed at various points around the axis, and not in linear series. In this species the polyps are very distant, apparently in two or three irregular rows. I know of no other species approaching it in this respect, but an examination of the polyps is necessary before its generic position can be definitely

established. In form and distribution they appear more closely related to *Cirripathes* than to any other genus of which the polyps are known. Haeckel, in explanation of his figure, says:—"Ein verzweigter Korallenstock, dessen sechszählige kleine Personen (mit sechs einfachen Tentakeln) zerstreut in der dünnen Rinde des Stockes sitzen; seine Axe wird durch ein schwarzes, glasähnliches Skelet gebildet." In the figure referred to, the basal expansion of the sclerenchyma is relatively large; the stem is only simple for a short distance, and then becomes subdivided at near the same point into four branches. Two are short and dichotomous, the other two longer, flexuose, not spreading, and branched dichotomously. The secondary branches in these cases bear two or three short branchlets at irregular intervals. The whole corallum only shows a slight taper from base to apex. The polyps are from $\frac{1}{2}$ to 3 diameters apart, arranged in two or three irregular rows. Lamarck's reference to the cortex is of no value here, having been written at a time when *Antipathes* was supposed to be a genus of Gorgonidæ. Lamarck distinctly refers to the presence of spines, and I am at a loss to know why Milne-Edwards included this species in his genus *Hyalopathes*, one of the characters of which is a *smooth* axis. I have not seen the species, but there seems every probability that the sclerenchyma, in spite of its being glossy, has the essential Antipatharian characters.

Habitat.—East Indies? (Lamarck); Tur, Red Sea (Haeckel).

[*Antipathes*] *picea*, Pourt.

Antipathes picea, Pourtalès, Bull. Mus. Comp. Zoöl., 1880, p. 115, pl. iii. figs. 9 and 29.

Corallum branching, flabellate; branches with four rows of pinnules, two of which remain generally small and simple; the other two develop more and give a pinnate appearance to the branches. The larger branchlets are again beset with small pinnules on one side. Spines subtriangular, about as high as broad near the apex of a pinnule.

Polyps small, with large spherical buccal knobs and flattened tentacles, with slightly incised border; when strongly contracted they appear globular. They are thickly beset with bundles of nematocysts. The polyps are rare on the thicker branches, and have distant and rudimentary tentacles; on the main stem very few buccal knobs are found, and these are destitute of tentacles. Height of the corallum 20 to 25 cm.

The polyps of this species, judging from the figure given by Pourtalès, appear to resemble those of *Cladopathes plumosa*, but it is not known if the zooids are dimorphic. The spines near the tip of a pinnule recall the form and arrangement of those of *Antipathella subpinnata* (E. & S.) in similar situations. The distinct crenations of the tentacles, should they not be due to batteries of nematocysts, may prove to be an approach to the pinnate condition in *Dendrobrachia*.

Habitat.—Off Grenada, in 291 fathoms; off Barbadoes, in 7 to 45 fathoms (Pourtalès).

[*Antipathes*] *tanacetum*, Pourt.

Antipathes tanacetum, Pourtalès, Bull. Mus. Comp. Zoöl., 1880, p. 116, pl. iii. fig. 13.

Mode of branching the same as in *Antipathes picea*, Pourt., from which it differs chiefly by the spines, which are here three times as long as broad.

Specimens mostly with simple stem, rarely branching a few times, appearing like a leaf of tansy or yarrow. On the lower part of the stem the spines become very slender and branched like miniature deer-horns, forming a velvety covering, which becomes filled with sand, sponge spicules, &c. The polyps were badly preserved, but they are evidently very small.

Most specimens have a parasitic worm, resembling, and perhaps identical with, the one which produces the tube in *Parantipathes columnaris* (Duch.); here, however, it remains applied to the stem, partly protected by branchlets, but producing no change in their growth.

Although this species has a type of corallum closely resembling that of [*Antipathes*] *picea*, Pourt., it is probable that its elongate subcylindrical spines may indicate a different type of polyp and also a different generic position. The spines recall the form and arrangement in certain species of the genus *Aphanipathes* and also the ultimate form of spine in *Antipathella subpinnata*. Its proper position must be left for future investigators to decide.

Habitat.—At a depth of 88 to 170 fathoms at eight stations, off Santa Cruz, Montserrat, Dominica, Martinique, the Grenadines, and Grenada (Pourtalès).

[*Antipathes*] *arctica*, Lütken (Pl. XII. fig. 26).

Antipathes arctica, Lütken, Oversigt Kongl. Danske Vidensk. Selsk. Forhandl., 1871, p. 18.

Lütken's description is as follows :—

"Sclerobasis (axis) cornea, nigra vel nigro-fusca, spinosa, arborem humilem, latiorem quam altiorem constituit; stipes erectus, teres, gracilis, niger, basi lævis, ceterum spinulis brevissimis, longitudinaliter seriatis, cum sulculis minutis alternantibus, asper; rami (primarii) patentissimi, horizontales fere, bifariam dispositi, utrinque 10 vel ultra, gracillimi, asperi, colore dilutiore, ramulos (secundarios, tertiarios) similes emittunt, angulos rectos cum ramis (primariis, secundariis) formantes, sursum, deorsum vel antrorsum inclinatos; rariter coalescunt. Superficies dorsalis vel posterior arboris totius ramulis omnino caret. Altitudo c. 5 pollices, latitudo 6½ poll."

The branches and branchlets arise in pairs, which are subopposite; all are placed nearly at right angles with the larger branches from which they arise, and in such a manner that the hinder surface of the specimen is without branches, all the secondary and tertiary branches being turned more or less towards the anterior surface. The occasional fusions between the branches have more the character of adhesion than

confluence. The species is quite unlike any which I have seen, and I am unable to suggest its affinities.

Professor Lütken has obtained a second specimen from Greenland, which is 16 cm. high, 22 cm. broad, and 9 cm. thick. The stem is nearly straight, and has a very broad dilation at the base. It gives rise to a number of long branches from the antero-lateral margins at right angles, which are usually in pairs and subopposite. The pairs are about 1 cm. apart. The main branches, some of which are 14 cm. long, again bear branchlets in pairs (about three pairs in 4 cm.), and at right angles, from the antero-lateral margins. The branchlets may reach 8 cm. in length; those over 6 cm. usually bear a single secondary branchlet. Fusions are frequent in all parts of the colony. The older parts of the corallum are dark and glossy, the others have a bright reddish brown tint, and are semitransparent. The spines are flattened, and have an elongate slender apex standing out at right angles to the axis. They are disposed in longitudinal rows, nine or ten of which may be counted from one aspect of a branchlet. The spines in some of the rows are numerous, one to two lengths apart; in others they are placed at irregular intervals, which are sometimes very great (Pl. XII. fig. 26).

Habitat.—North Greenland. One specimen was obtained from the stomach of a shark (*Scymnus microcephalus*).

[Genus *Arachnopathes*, M.-Edw.]

"Axe sclérobasique se divisant en une multitude de branches très-grêles qui se dirigent en divers sens et se soudent entre elles aux points de rencontre, de façon à constituer des réseaux dont la réunion forme une touffe arrondie" (M.-Edw., *op. cit.*, p. 320).

The only character by which the species referred to this genus can at present be separated from other Antipathidæ, consists in the fact that the branches and their derivatives are fused into a mass several centimetres in thickness, instead of being flat. In the absence of information concerning the polyps this genus is retained temporarily.

Arachnopathes ericoides (Pall.), M.-Edw. (Pl. XI. fig. 22).

Antipathes ericoides, Pallas, Elench. Zooph., p. 218; Esper, Pflanzenth., pl. vi.; Lamarck, &c.
Arachnopathes ericoides, M.-Edwards, Coralliaires, t. i. p. 320.

"A. ramosissima, hispidissima, atra, ramis sparsis, ramulis ubique crebris subulatis" (Pallas, *op. cit.*).

This species constitutes the type of M.-Edwards' genus *Arachnopathes*. The following is his description:—"Branches grêles, nombreuses, très écartées entre elles, très finement échinulées, et ne différant presque pas des ramuscules." There is a specimen in the British Museum which appears to be the species described by Milne-Edwards, but I am uncertain as to its identity with the original type of Pallas. The mode of branching is

so peculiar that it seems inexplicable why, if Pallas had this form before him, he failed to give a better definition of it. The mode of branching agrees with Milne-Edwards' generic characters, and the whole corallum is fused into a dense mass, 28 cm. high, 36 cm. wide, and 10 cm. thick. The stem is relatively slender, and gives rise, close to the base, to a large number of branches in all directions. All the main branches, after a certain course, grow up subvertically. They vary in thickness, and present dilations here and there without regularity. Each branch is beset with a number of short spirally arranged pinnules, which are curved slightly upwards, but have an insertion almost at right angles to the branch. There may be from three to five in one revolution of the axis, and about six or eight to a centimetre. These pinnules vary very much in length, many are slender, only slightly tapering, and from 1 to 1·5 cm. long; others which are longer bear secondary pinnules. These may be 5 cm. long, arched upwards, so that the apex takes a subvertical direction, and then bear secondary pinnules spirally arranged, and varying from 0·5 to 1·5 cm. or more in length; most are simple, but a few become again divided. The whole corallum is fused into a firm mass, not so much by a confluence of parts as by frequent adhesions between the pinnules of adjoining branches and branchlets. At almost every point of contact a fusion takes place. The spines are elongate, and somewhat related in form to those of some species of *Aphanipathes* (*e.g.*, *Aphanipathes barbadensis*). A spiral arrangement is not well marked, but the spines are arranged in longitudinal rows, of which five may be seen from one aspect. The spines are about equal in length to the diameter of the axis in their neighbourhood, and are laterally compressed, ending in a blunt point formed by the lower margin taking a sharp curve upwards to join the upper margin. The members of a row are usually separated by an interval greater than the length of a spine (Pl. XI. fig. 22). There are a number of specimens in the Zoological Museum at Copenhagen which appear to belong to this species, but differ from M.-Edwards' type, in having a more slender corallum, the branchlets of which are irregularly placed, not in a distinct spiral. The largest specimen is 41 cm. long, 30 cm. broad, and 13 cm. thick. The stem near the base has a diameter of 3 mm. The whole outer, and particularly the upper, portion of the corallum is very slender; there is scarcely any difference between the thickness of the branches and branchlets. The spines are distinctly visible to the naked eye.

Habitat.—Indian Ocean (Pallas, &c.).

Arachnopathes clathrata (Pall.), M.-Edw.

Antipathes clathrata, Pallas, Elench. Zooph., p. 212.
Arachnopathes clathrata, Milne-Edwards, Coralliaires, t. i. p. 320.

" A. ramosissima intricata, ramulis confusis ubique coalescentibus, junioribus setaceis. Fruticulus modo pedali major, rariusculus; modo vix semipedalis densiusque ramosus;

semper in latum expansus, rigidus, inordinatus. Truncus ab imo fere ramosus, creberrime subdivisus. Rami divaricati curvuli confusique assurgunt, creberrimisque ramulis alternis vel subsecundis, reclinatis fere, inter se coalescunt; junioribus passim, setaceis sparsi. Lignum atrum, scabrum, setaceis ramulis hispidius, subtestaceum" (Pallas, *op. cit.*).

Morison's specimen (6, No. 18, pl. x.), which Pallas includes in this species, has, as already stated, a close resemblance to the lower part of the corallum of *Antipathella contorta*. The branches are strong, and form an irregular reticulum; the branchlets are extremely slender, pinnate or bipinnate. It does not appear from the definition of Pallas that much stress is laid on this marked contrast between the thickness of the branches and branchlets.

An old and fragmentary specimen in the British Museum may possibly be referable to this species, but the branchlets are not nearly so delicate as those figured by Morison. This specimen differs from all other Antipathinæ, with the exception of the genus *Arachnopathes*, M.-Edw., as I understand it, in possessing a corallum which, though flattened, is 6 or 8 cm. thick. A figure of the arrangement of the spines in this specimen is given on Pl. XI. fig. 10.

Habitat.—Indian Ocean.

Arachnopathes aculeata, n. sp. (Pl. XI. fig. 11).

Corallum consisting of a delicate oval mass of branches and branchlets 24 cm. high, 20 cm. broad, and 11 cm. thick. The branchlets and pinnules are somewhat flexible, and not fused into such a firm mass as in other species of the genus. The branches are slender and irregularly divided. The branchlets in the upper portion of the corallum are from 3 to 5 cm. in length and about 0·3 mm. in thickness. They bear a number of more slender pinnules, mostly sublateral, but a few extend in a plane almost at right angles to the others. They are from 0·5 to 1·5 cm. long, usually simple, and rather irregularly arranged, about two to four to a centimetre. Near the middle of the specimen the branchlets are longer and stronger, and bear a greater number of pinnules, most of which spring from the same side of the branchlet. In one portion, which may be taken as an illustration, twenty-three pinnules occur to 5 cm. They are chiefly lateral in position, and fifteen are arranged on one side and only eight on the other. The eight pinnules on the one side are all simple, and vary from 0·5 to 1·5 cm. in length. Those on the other side are usually longer (1·5 to 2·5 cm.), and bear a secondary and sometimes a tertiary series of pinnules, but two or three remain short and simple. The longer pinnules bear two to seven secondary spreading pinnules, mostly on one side, and directed downwards. Some of the secondary pinnules may be 1 to 1·5 cm. long, and

then bear two to four short tertiary pinnules, frequently, but not invariably, on one side only. The majority of the primary pinnules and their derivatives are usually free, but the branchlets are united together by one or two pinnules from adjoining branchlets, which become fused together. The spines are short and conical, with a sharp apex, and stand out almost at right angles to the axis. A spiral arrangement is fairly well marked in both directions, but the dextrorse spiral is steeper than the one in the opposite direction. The spines are also disposed in longitudinal rows, five of which may be counted from one aspect of a pinnule. The members of a row are three to four lengths apart. A few of the spines have a forked apex (Pl. XI. fig. 11).

Habitat.—Aru Islands (Wallace), Brit. Mus.

Group A. Antipathidæ Myriophylloides.

Species related to *Antipathes myriophylla*, Pall., in type of branching.

[*Antipathes*] *myriophylla*, Pall. (Pl. XII. fig. 1).

Antipathes myriophylla, Pallas, Elench. Zooph., p. 210; Esper (pt. ii. p. 180); Dana, Zooph., p. 578; Gray, Proc. Zool. Soc. Lond., 1857, p. 292; Pourtalès, Bull. Mus. Comp. Zoöl., 1880, pl. iii. fig. 23.
Antipathes myriophilla, Milne-Edwards, Coralliaires, t. i. p. 316.

"A. incurva ramosissima pinnatulataque, ramis sparsis divaricatis, pinnulis rarius culis setaceis, hinc ramosis" (Pallas, *loc. cit.*).

Main axis usually repeatedly bent at right angles, alternately to the right and left. From the angles thus formed short tapering branches are given off. Stronger branches occur at irregular intervals along the stem. The primary branchlets are usually bipinnate, occasionally tripinnate, and the pinnules are usually opposite and closely set, bearing a number of short, usually simple, though sometimes forked, processes, which are all situated on the *anterior surface* of the pinnules and directed forwards. On this account the whole of the anterior surface of the corallum has a more complex structure than the posterior. The whole of the branching takes place in one plane, with the exception of the short secondary pinnules referred to.

Esper gives a fair figure of this species (**21**, pl. Antip. x.). The spines are subconical and hooked upwards. They are much crowded, and arranged in regular longitudinal rows, six or seven of which may be seen from one aspect of a pinnule. The members of a row are not more than half a length apart. A spiral arrangement may also be made out both from left to right and in the opposite direction (Pl. XII. fig. 1).

Habitat.—Indian Ocean (Pallas); Batavia (Ellis), Philippines (Cuming), Brit. Mus.

[*Antipathes*] *panamensis*, Verrill.

Antipathes panamensis, Verrill, Notes on Radiata, No. 6, Trans. Connecticut Acad., 1869, p. 499.

"Corallum arborescent and densely branched, and finely subdivided, small branches mostly bi- and tri-pinnate. Trunk stout, and subdivides irregularly into many branches, which again divide in the same way. Resulting smaller branches arise along the sides of larger branches, at distances of ·08 to ·20 of an inch—many remaining small, simple, or sparingly divided, but mostly pinnate, bipinnate, or even tripinnate. Final branchlets are ·08 to ·10 inch apart, small, slender, rather short, rarely more than ·15 inch long without branches, scarcely ·02 inch diameter. Their surface densely covered with small sharp spinules, directed obliquely outward and towards tip of branchlets. Colour of trunk and main branches dull brownish-black, branchlets very dark brown. Height 13 inches, breadth 10 inches, diameter of trunk ·50 inch, of main branches ·15 to ·25 inch."

Habitat.—Off Pearl Islands, Panama Bay, in 6 to 8 fathoms.

[*Antipathes*] *ulex*, E. and S. (Pl. XI. fig. 5).

Antipathes ulex, Ellis and Solander, Zoophytes, p. 100, pl. xix. figs. 7 and 8; Gray, Proc. Zool. Soc. Lond., 1857, p. 292.

? Antipathes mimosella, Lamarck, Hist. nat. anim. sans vert., t. ii. p. 307; Milne-Edwards, Coralliaires, t. i. p. 317.

? Antipathes pinnatifida, Lamouroux, Polyp. flex., p. 377, pl. xiv. fig. 4; Studer, "Gazelle" Exped., Monatsber. Berlin Akad., 1878, p. 548.

Ellis and Solander's description of this form is very unsatisfactory:—"A. ramosissima, ramis sparsis, patentibus, hispidissimus attenuatis. . . . . The branches stand out loose and irregular, and the whole specimen is particularly full of small short spines; axis remarkably black."

There appears some uncertainty as to the identity of Lamarck's form *Antipathes mimosella* and of its synonym or close ally *Antipathes pinnatifida*, Lamx. Dana and Gray have both regarded Lamarck's species as identical with *Antipathes ulex*, E. and S. Lamouroux, on the other hand, in describing his species *pinnatifida*, says that it may agree with Lamarck's form, but that it certainly differs from Ellis and Solander's. Lamarck has given us no figure of *Antipathes mimosella*, nor has any subsequent investigator, so far as I can ascertain. A comparison of Ellis and Solander's figures with those of Lamouroux would lead one to suppose that the two forms are distinct.

In the figure of *Antipathes ulex* the pinnules are represented as slender, spreading, and laxly pinnate, occasionally forked, in which case each fork bears pinnules on one side only. One strong pinnule, almost as thick as the branchlet from which it springs, is in its upper portion bipinnate.

In Lamouroux's figure of *Antipathes pinnatifida* the pinnules are stronger, subopposite, more closely packed, not so patent, and all, unless very short, are bipinnate, the ultimate

pinnulæ being very short and directed forwards from the antero-lateral margin, thus approaching *Antipathes myriophylla*, Pallas.

From a comparison of specimens in the British Museum, I am led to think that both may be varieties of the same species, and it is easy to find specimens, from different portions of which one might obtain figures similar either to those of Ellis or of Lamouroux. The specimens recorded by the various observers, being all from the East Indies and Philippines, makes it more probable that the different forms described may be varieties of one species.

The specimen in the British Museum which Gray referred to *Antipathes ulex*, E. and S., shows marked variations in the mode of branching in different parts of the colony. The branches are spreading in one plane, and both branches and branchlets are patent, glossy black, tapering, pinnate or bipinnate. In the middle portion of the colony the pinnules are subalternate, reddish brown in colour and directed anteriorly, occasionally simple, but usually alternately pinnate or bipinnate, and average 1·8 to 2·5 cm. in length. They are much more slender than the branchlets from which they arise. Only when the pinnules become 3·7 to 5 cm. long do their bases assume the glossy black aspect of the stem and branches. In the apical portion of the colony the arrangement is somewhat different, leading in extreme cases to short subtriangular fronds about 3·7 to 5 cm. in length, agreeing more nearly with Lamouroux's figure. Here the branchlets taper quickly, and the pinnules are subalternate and closely packed; the basal pinnules are relatively strong and bipinnate; their secondary pinnules and the primary ones nearer the tip all bear short spinous processes, arising from the antero-lateral margin, usually on one side only, but occasionally on both. These are directed obliquely forwards and outwards. There appear to be no fusions in any part of the colony, although pinnules from adjoining branchlets frequently overlap one another.

The spines (Pl. XI. fig. 5) are longer, straighter, and not so strong as those of [*Antipathes*] *myriophylla*, and the apex is not hooked upwards. They present a similar spiral arrangement, but the members of a row are fully one length apart. Pending further investigation on the subject, it thus seems advisable to regard Lamarck's and Lamouroux's species as probably synonymous with that of Ellis.

Habitat.—Batavia (Ellis); East Indies and Philippines, near Island of Luçon (Lamarck); Indian Ocean (Lamouroux); Philippines (Gray), Brit. Mus.; Mermaid Channel, "Gazelle" Expedition (Studer).

[*Antipathes*] *spinosa* (Carter) (Pl. II. fig. 12).

Hydradendrium spinosum, Carter, Ann. and Mag. Nat. Hist., ser. 5, vol. v. p. 454, pl. xix. fig. 8.

Stem erect, branched, branches subalternate, about 1 mm. apart, irregular in length, and disposed around the stem, sometimes subdivided. The shorter branches are simple,

and bear one or more pinnules on one side only; the longer ones are regularly and alternately pinnate, the pinnules being very slender and usually provided with one to three very short secondary pinnules, chiefly on one side. Stem and stronger branches distinctly tapering, other portions of the corallum very slender. Height 5 cm., diameter in broadest part 4·5 cm. Diameter of the base of the stem 0·4 mm. Spines somewhat conical, and hooked upwards, arranged more irregularly than in *Antipathes ulex*, and without a marked spiral arrangement (Pl. II. fig. 12). I have not found the arrangement so regular as that shown in Carter's figure. Near the base of the stem the spines become very much elongated, and dendritic towards the tip, a character observed in other species, but not, so far as I remember, in *Antipathes ulex*, E. and S.

This species was regarded by Carter as the type of a new genus of Hydractiniidæ; there can, however, be no doubt that it belongs to the Antipathidæ, and is very closely related to *Antipathes ulex*, E. and S.; it may indeed be a very young form of that species. Mr. Moore, of the Liverpool Free Museum, has very kindly sent me a slide of this species, an examination of which shows the spines to have a different arrangement to those of *Antipathes ulex*, though in both, as also in *Antipathes myriophylla*, Pallas, they are distributed in a similar manner. In Carter's form the branches are not confined so much to one plane as is the case in typical *Antipathes ulex*.

For the present Carter's form is regarded as distinct, but the whole of the forms included in this section require further examination before reliable specific characters can be obtained.

Habitat.—Gulf of Manaar (west coast of Ceylon), in 65 fathoms (Captain Cawne Warren).

[*Antipathes*] *japonica*, n. sp. (Pl. XI. fig. 25).

Corallum small and laxly branched; branches bi- and tri-pinnate, with the subdivisions directed inwards as in the leaf of the Tansy (*Tanacetum*).

The stem has a rounded basal dilation for attachment, and has a diameter of 2·25 mm. below. Branches few, irregularly arranged, 7 to 9 cm. long, tapering, and bearing close-set alternate rows of rigid branchlets, 1 to 4·5 cm. long. These arise from a point slightly in front of the lateral margin of the branches, and are somewhat recurved. The smaller ones are simple, but most of them bear a number of alternate pinnules springing from the antero-lateral margins, which may be simple, but usually bear a further series of one to five short secondary pinnules, which again are not truly lateral, but have an anterior or antero-lateral insertion. In the mode of branching this species is intermediate between *Antipathes bifaria*, in which the two series of branchlets include a narrow acute angle, and *Antipathes myriophylla*, &c., in which the branchlets are lateral and the whole corallum in a plane, excepting the short setose pinnules, which in all the species of this section are directed more or less anteriorly. Spines moderately numerous, of a length

equalling the diameter of the axis, elongate, subcylindrical, compressed laterally. The spines are probably arranged in spirals, but their course is difficult to make out. They are arranged in longitudinal rows, six of which may be counted from one aspect. The members of each row are separated by an interval about equal to the length of a spine. The base of a spine is not much dilated, and the diameter decreases little until near the apex, when the lower margin curves rapidly upwards, forming with the upper margin a blunt point (Pl. XI. fig. 25). The type is in the British Museum (Reg. No. 83.8.29.6).

Habitat.—Off Inosima Island, Japan (Burge).

[*Antipathes*] *bifaria*, n. sp. (Pl. XI. fig. 20).

Corallum large and much branched, 90 cm. high, stem thick and sinuous, with strong branches, several of which are 24 to 30 cm. long. There is a sudden transition from the strong stem and branches to the slender branchlets and pinnules which they bear. The pinnules are usually arranged in a double row, enclosing a very narrow acute angle and directed upwards, or there may be only a single row. They are from 0·5 to 2·5 cm. in length, situated near the upper margin of a branchlet, and are directed forwards. The longer ones bear two to six secondary pinnules, all springing from near the anterior surface, and from 0·3 to 1·3 cm. long. The longer ones may again bear two or three secund pinnules of a tertiary series.

The spines (Pl. XI. fig. 20) are very similar to those of *Antipathes myriophylla*, but are less hooked and not so crowded. The members of a row are one length apart.

Habitat.—Formosa (Swinhoe), Brit. Mus.

Group B. Antipathidæ cupressoides.

Corallum more or less cylindrical, of the "bottle-brush" type.

[*Antipathes*] *abies* (Linn.), Gray (Pl. XI. fig. 21).

Cupressus marina, Seba, Thesaurus, t. iii. pl. cvi. fig. 1; Rumph., Herb. Amb., t. vi. pl. lxxx. fig. 2.
Gorgonia abies, Linnæus, Syst. nat., ed. xii., p. 1290.
Antipathes cupressina, Pallas, Elench. Zooph., p. 213; Esper, Pflanzenth., Abth. ii. p. 143, pl. iii.
Antipathes cupressus, Ellis and Solander, Zoöph., p. 103; Lamarck, Hist. nat. anim. sans vert., t. ii. p. 307; Lamouroux, Polyp. flex., p. 380; Encycl. méthod., t. iv. p. 71; Dana, Zooph., p. 581; Milne-Edwards, Coralliaires, t. i. p. 316.
Antipathes abies, Gray, Proc. Zool. Soc. Lond., 1857, p. 292.
Antipathes paniculata, Esper, Pflanzenth., Fortsetz., Abth. i. p. 184, pl. xii.; Lamouroux, Dana, &c., *non* Duchassaing.

Stem simple, or more rarely bearing one, two, or more branches, straight or somewhat flexuose, tapering. Branches usually short, stout, quickly tapering, paniculate, all

with a well-marked dextrorsal curvature. They are very closely packed, and arranged subspirally around the axis. The arched branches bear a double alternate row of branchlets on the antero-lateral margins, which in turn bear a number of simple or branched pinnules on the anterior margin. The paniculate branches may be 6 cm. long and 4 cm. across the branchlets. The stem may be 60 cm. or more in length. The length of the branches does not always bear a definite relation to the length of the stem. There are several specimens of this species in the British Museum. Two from Mauritius are 60 cm. long; one has a diameter across the branches of 12·5 cm., the other only 9 cm. In the former the stem bifurcates near the apex, in the latter the stem is simple. In other cases the stem may be continued in a vertical direction, and give rise to from two to four strong branches of no great length, each of which bears the same arrangement of branches and branchlets as the main stem. The diameter of the corallum varies little, excepting near the apex, where the branches gradually become shorter. This species, on account of its closely-set paniculate branches, has a general resemblance to a bottle-brush. It may readily be distinguished from other species having the same type of corallum by its arched branches, all of which have a marked dextrorsal curvature. The spines are subcylindrical and slightly hooked upwards, the lower margin distinctly convex, the upper only slightly concave, having a length about equal to half the diameter of the axis. They are arranged in irregular dextrorse spirals, and also in longitudinal rows, six or seven of which may be seen from one aspect. The members of a row are separated from each other by a space equal to or exceeding the length of a spine (Pl. XI. fig. 21). Zooids not known.

Var. *paniculata*, Esper.

Under the name *Antipathes paniculata*, Esper described a form similar to the typical *Antipathes abies* but having more elongate branches. Lamarck considered this form to be referable to *Antipathes cupressina*, Pallas (=*Antipathes abies* (Linn.)), but Dana thought the two forms might be distinct. A specimen in the British Museum referable to Esper's species is 48 cm. long. It differs only from typical *Antipathes abies* (Linn.), in having longer and more lax branches, the basal portions of which are usually devoid of branchlets. The arrangement of spines is the same in both forms. The branches vary from 8 to 18 cm. in length. On account of the greater and more irregular development of the branches, this form does not at first recall the "bottle-brush" type, but can only rank as a variety.

Habitat.—Type.—Indian Ocean (Pallas); Banda Sea, &c. (Esper); Philippines (Gray), Mauritius, 70 fathoms (Brit. Mus.).

Var. *paniculata.*—Banda Sea (Esper); Ceylon (Ondaatje), Brit. Mus.

[*Antipathes*] *pumila*, n. sp. (Pl. XI. fig. 17).

A small species resembling *Antipathes abies*, var. *paniculata*, in habit, but having short and more slender paniculate branches and more elongate spines. The corallum is slender, 9 cm. long and 6 cm. broad. The stem is straight, and the branches are arranged subspirally, four or five in one revolution of the axis; they are from 1 to 6 cm. long. Those about 3 cm. long bear eighteen to twenty-two subalternate branchlets, most of which are lateral or antero-lateral, but a few arise from the posterior surface. Frequently the longest and most complex branchlet (2 cm.) is inserted on the posterior surface of the distal half of a branch. Many of the branchlets are short and simple, but others bear two to five subsecund secondary branchlets, not all in one plane, but all directed towards one aspect. Some of these may again bear a short tertiary subsecund series. Occasionally one or two of the secondary branchlets, like those of the primary series, spring from the posterior surface of the axis. Ultimate branchlets 0·25 to 0·75 cm. long. Spines elongate, tapering, and directed upwards from a narrow base. They resemble those of *Aphanipathes wollastoni* closely in form. They are arranged in dextrorse spirals and also in longitudinal rows, six of which may be counted from one aspect of a branchlet. The members of a row are usually rather less than one length apart.

Habitat.—Kurrachee (Murray), Brit. Mus.

[*Antipathes*] *cylindrica*, n. sp. (Pl. IV. figs. 5–7).

Stem simple, erect, tapering, with five or six horny Annelid tubes closely applied to it; length of the larger specimen 32 cm., diameter at base 4 mm., near apex 0·6 mm. Only the apical 20 cm. now bears branches (Pl. IV. fig. 5). These are very closely set, subverticillate, or in a very close spiral, usually in four rows. The branches are relatively strong and short, much divided and subequal in length, giving a bottle-brush type of growth. The greatest diameter is about 4 cm. The branches are strong at first and taper rapidly to a hair-like point. Near the base they usually become forked (Pl. IV. fig. 6), and about the same point may bear an elongate and more slender branchlet, the whole three subequal in length, and separated from each other by a wide angle. Each arm of the main branch bears a number of irregularly pinnate or bipinnate branchlets, most of which are directed obliquely downwards. Fusions are frequent between the primary arms of the branches, but the pinnate branchlets are always free. The degree of complexity differs greatly in adjoining branches. Some bear elongate branchlets, which are simple or forked, others bear a tertiary series of branchlets. The branches and branchlets are all straight and rigid. The spines are short and triangular, distributed in a spiral manner and also in longitudinal rows, six of which are visible from one aspect. The members of a row are

separated by intervals more than equal to the length of a spine (Pl. IV. fig. 7). The polyps are not preserved. A number of horny Annelid tubes are applied to the stem of the type specimens.

Habitat.—Station 192; September 26, 1874; lat. 5° 49′ 15″ S., long. 132° 14′ 15″ E., off Ki Islands; depth, 140 fathoms; bottom, blue mud. Two specimens.

[*Antipathes*] *spinescens*, Gray (Pl. II. fig. 8; Pl. XI. fig 24).

Antipathes spinescens, Gray, Proc. Zool. Soc. Lond., 1857, p. 292.

"Coral branched, branches divaricating, subcylindrical; branchlets on all sides of the stem, crowded, short, of nearly equal length, straight, spine-like, with spine-like branches and branchlets on their sides; the lower branchlets sometimes tending toward one surface" (Gray, *loc. cit.*).

The stem is 2 to 2·5 mm. in diameter, and tapers rapidly above. The branches are very irregular in length, the stronger ones being 6 to 9 cm. long and 1·5 to 2 mm. in diameter at the base. In one portion of the specimen the branches form an acute angle with the stem, and are placed entirely without order. In another portion the branches extend in a subhorizontal direction and have branchlets 2 to 10 cm. long rising subvertically. Sometimes three or four branchlets are collected together in a cluster. The whole axis is densely clothed with branched pinnules, forming an acute angle with the axis, arranged in very close spirals (?) and subequal in length, giving the appearance of a bottle-brush in which the bristles are directed upwards instead of horizontally, and about 2 to 2·5 cm. in diameter.

The stem and branches bear four rows of closely-set and strongly spinose pinnules, arranged in a close spiral, and in such a manner that the bases of the pinnules form four longitudinal series, subequidistant. The spiral is from left to right. Each pinnule is forked near the base, that fork passing out in the direction of the spiral being usually longer than the other. Both bear secondary and sometimes short tertiary pinnules; most of them arise from the lateral margin, but frequently one or more spring from the *under* surface and are directed downwards and forwards. For the precise mode of arrangement see Pl. II. fig. 8. The primary pinnules are from 9·5 to 15·5 mm. long, and one occupies a position nearly at right angles to the stem. The effect is a bottle-brush form about 2·5 cm. in diameter. Occasionally and at irregular intervals a pinnule becomes elongate and thickened, and then bears a close-set spiral of pinnules. These by increase in importance form the branches of the stem.

Sclerenchyma black on the stem, golden brown in the pinnules.

The spines are elongate, often slightly curved upwards, and are distinctly longer on one side than on the other (Pl. XI. fig. 24). They are similar in shape to those of *Antipathes pennacea*, Pall., but are not all subequal. They are close set in longitudinal

rows, seven of which may be counted from one aspect of a branch. The members of a row are under one length apart in the case of the longer spines. Towards the base of a branch the disproportion in size is much more marked than is shown in the figure (Pl. XI. fig. 24), those on one side becoming quite short and pointed, whilst those on the opposite side retain their normal size.

Habitat.—Cape Palmas (Hooker), Brit. Mus. (Reg. No. 43.2.3.110).

Var. *minor*, nov. (Pl. II. fig. 9).

Stem and mode of branching unknown. Branches bearing straight branchlets from 7 to 9 cm. long, forming a wide angle with the stem. These are clothed from near the base to the apex with a short, much divided set of pinnules, which are subequal in length, giving a bottle-brush form only 1·25 cm. in diameter. The pinnules are short, arranged spirally, and stand out nearly at right angles to the branchlet; they are much flattened and bifurcated near the base, each portion having two to five secondary lateral pinnules arranged alternately, from 1·5 to 6 mm. long, the longest of which have occasionally a short tertiary pinnule placed on the outer antero-lateral margin (Pl. II. fig. 9).

The spines have a similar arrangement to that in the type specimen of *Antipathes spinescens*, Gray. Colour of the sclerenchyma greyish olive.

Two branchlets only were found in the British Museum Collection along with *Antipathes spinescens*, Gray, and labelled *Antipathes spinescens* in Gray's handwriting. This form is, however, distinguishable at a glance from Gray's type.

Habitat.—Not recorded, but possibly not the same as the type, as it was obtained five years later. Brit. Mus. (Reg. No. 48.8.32.2).

[*Antipathes*] *squamosa*, Koch.

Antipathes squamosa, W. Koch., Neue Anthozoen a. d. Golf. v. Guinea, p. 9, pl. ii. fig. 5, 1886.

Koch's type consisted of a specimen with two stems arising from the same base, 19 and 21 cm. in length respectively. The shorter one was almost without branches, the longer, in its upper portion (12 cm.), bearing a number of branches having almost the same diameter as the stem. The branches come off in all directions, giving a bottle-brush form, tapering somewhat above. The branches have the following arrangement:—A main branch (1) bears one, two, or, more rarely, three secondary branches (2), which in their turn may bear branchlets of a third order (3). All the secondary branches are borne on the same side of the primary ones, and are directed downwards. The branches

are arranged on the stem in such a manner that the whole of each of the series, one, two, and three, are almost parallel with one another, giving a very regular growth. The primary branches are relatively close set, about three or four to a centimetre.

The spines are apparently short and much crowded, showing a subverticillate arrangement (*cf.* Koch, **76**, pl. ii. fig. 5, *b*).

This species appears very closely allied to *Antipathes spinescens*, Gray, if, indeed, it be not identical with it; both types come from the same area.

Habitat.—Rolas (Gulf of Guinea), Koch.

. . . . . .

The following species are too imperfectly defined for identification :—

[*Antipathes*] *alopecuroides*, E. and S.

Antipathes alopecuroides, Ellis and Solander, Zoophytes, p. 102.

"Antipathes ramosa, ramis arcte paniculatis hispidis setaceis.

"The trunk of this Antipathes rises from a broad spread base, and divides immediately into several large branches of $\frac{1}{3}$ of an inch diameter; . . . . one side of them appears flat, with a groove or channel along the middle of it, where there are the remains of many little branches that have grown in rows on each side of it. It then divides into branches, and often into other branches, all which are in form of close panicles, not unlike the fox tail grass. These panicles are composed of very rough, thorny, minute branches, which are twice as long on one side of the stem as the other . . . . . It is near 2 feet high" (*Op. cit.*).

Habitat.—Off South Carolina.

[*Antipathes*] *triquetra*, Brug.

Antipathes triquetra, Bruguière, Encycl. méthod., p. 82; Lamouroux, Polyp. flex., p. 374.

"A. subflexuosa; ramis raris; ramulis subspiralibus, triquetris" (Brug., *op. cit.*).

Stem simple, very thick, bearing three or four branches irregularly, which, like the stem, have a somewhat triangular outline. "On apperçoit sur la crête des angles qui descrivent une spirale autour de la tige et des rameaux, des impressions assez serrées qui designent les pinnules dont les angles etaient garnis, et dont il reste en quelques endroits une faillie d'un quart de ligne; tout la superficie est herisseé de poils bruns roides et courts, sur lesquels on voit par intervalles des crôutes muqueuses qui les couvrent en partie" (Brug., *loc. cit.*).

Habitat.—Manila (Poivre).

[*Antipathes*] *lacerata*, Lamk.

Antipathes lacerata, Lamarck, Hist. nat. anim. sans vert., t. ii. p. 306; Milne-Edwards and Haime, Hist. nat. d. Coralliaires, t. i. p. 315; Dana, Zooph., p. 583.
Antipathes lacera, Lamouroux, Encyclop. méthod., p. 70; Polyp. flex., p. 377.

Lamarck's description is very short:—"A. caule ramoso, spinis echinato, ramis sarmentosis, tortuosis, sensim attenuatis; ramulis lateralibus, tenuibus sublaceratis." Habitat not ascertained, but Lamarck suggests that his specimen probably came from the Indian Ocean. Other authors copy Lamarck's description, and Lamouroux adds that the branches become intertwined as if for the purpose of support.

[*Antipathes*] *pectinata*, Lamk.

Antipathes pectinata, Lamarck, Hist. nat. anim. sans vert., t. ii. p. 306.
Hyalopathes pectinata, Milne-Edwards, Coralliaires, t. i. p. 323.

"A. in plano ramosa, flabellata, ramis compressis, pinnato pectinatis; ramulis filiformi-subulatis, subdivisis; spinis raris" (Lamk., *op. cit.*). Lamarck gives no locality. Milne-Edwards included this species in his genus *Hyalopathes*, characterised by having a vitreous instead of a horny axis, though on what grounds I am unable to say. The species has not been identified by subsequent investigators, and I am unable to offer an opinion on it.

[*Antipathes*] *americana*, Duch. and Mich.

Antipathes americana, Duchassaing and Michelotti, Mem. Acad. Torino, ser. 2, t. xix. p. 332.

"Simple, pinnée; les ramuscules sont très minces, et se dichotomisent assez souvent tout en conservant les mêmes dimensions. Axe noirâtre. Les ramuscules libres et non coalescent." The authors give no figure or further explanation.

Habitat.—St. Thomas.

[*Antipathes*] *taxiformis*, Duch.

Antipathes taxiformis, Duchassaing, Rev. d. Zooph. et Spong. d. Antilles, p. 22.

"Ramosa; ramis sparse pinnulatis, ac indè taxiformibus; pinnulis tenuissimè (oculo armato) echinulatis, nec nodoso-geniculatis."

In further explanation Duchassaing adds that the species is small, and its ultimate branches are disposed in a taxiform manner, the pinnules being scattered, and diminishing in length from below upwards, so that each small branch resembles a yew tree in miniature.

Habitat.—Off Island of Desirade (Lesser Antilles), in over 100 metres.

[*Antipathes*] *melancholica*, Duch.

Antipathes melancholica, Duchassaing, Rev. d. Zooph. et d. Spong. d. Antilles, p. 23.

Humilis, ramosa, ramis sparsis, distiche pinnatis; pinnulis remotis, per totam longitudinem alternatim nodosis ac strangulatis, inde quasi articulatis.

Duchassaing says that this form approaches *Antipathes dissecta*, D. and M., but may be distinguished by its smaller size, by its more isolated and robust pinnules, on which the "nodes" are less frequent. Further, the branches which bear the pinnules also have the "nodes," whereas in *Antipathes dissecta* this is not the case. The colour of the sclerenchyma is a greyish black. The difference between this form and *Antipathes dissecta*, D. and M., is evidently not great, so far as Duchassaing has noted it, and I should include it as probably synonymous with the latter species, were it not that I presume the "nodes" of which he speaks are really dried polyps, and not thickenings in the sclerenchyma. This view appears to be supported by Duchassaing's statement that "nodes" are present on the branches of *Antipathes melancholica*, and absent on those of *Antipathes dissecta*. In a small colony like that of *Antipathes melancholica* the polyps would probably be developed on both branches and pinnules, whereas in large ones (*Antipathes dissecta* is 2 to 3 feet high) there is a greater tendency for the polyps to be confined to the younger portions of the colony. Even should they prove to be successive series of longer and shorter spines, as in *Antipathes humilis*, Pourt., this would indicate that the polyps of this species are either larger or further apart (or both), a character which, taken with those already indicated by Duchassaing, would probably be sufficient justification for separating the two forms. This, however, is only supposition, and until we obtain more precise information on the subject, it may be well to keep the two forms separate. It should be mentioned that *Antipathes dissecta*, D. & M., has here been regarded as probably synonymous with *Leiopathes glaberrima*, Esper, in consequence of its similarity to that species and from the fact that the latter has been shown by Pourtalès to occur in the West Indies.

Habitat.—Off Desirade Island (Lesser Antilles), associated with *Antipathes taxiformis* (Duch.).

[*Antipathes*] *isidis-plocamos*, Klunz.

Antipathes isidis-plocamos, Klunzinger, Korallth. d. rothen Meeres, Abth. i. p. 61, pl. iv. fig. 5.
[*A. isidis-plocamos*, Ehrenb., Korallenth. d. rothen Meeres, p. 154.
? A. compressa, Esp., *pars*, Pflanzenth., Tab. xiii. fig. 1, *non* figs. 2, 3.]

Under this name Klunzinger has described some fragments of an Antipatharian from the Red Sea. The lower portion appears as if consisting of two stems fused together.

This portion is 2 to 3 cm. broad below, and 1 cm. above, and bears the bases of several branches which have been broken off. Other portions bear parts of branches. The sclerenchyma appears smooth, but under a lens is seen to be covered with very numerous fine wart-like spines (*cf.* Klunz., *op. cit.*, pl. iv. fig. 5).

Klunzinger regards his specimen as identical with that obtained from the same area by Ehrenberg, and as probably agreeing with Esper's *Antipathes compressa*, or rather with that specimen shown in his pl. xiii. fig. 1; his description and the other figures probably refer to a decorticated Gorgonid. Klunzinger's description is not sufficient for specific purposes, and is based on a very fragmentary specimen.

Habitat.—Red Sea.

GEOGRAPHICAL DISTRIBUTION.

List of the ANTIPATHARIA obtained during the Voyage of the Challenger, arranged in the order of the Stations at which they occurred, with information as to the depth and nature of the sea bottom.

Off St. Paul's Rocks; August 28, 1873; depth, 10 to 80 fathoms.

Pteropathes fragilis, n. sp.

STATION 145A.—December 27, 1873; lat. 46° 41′ S., long. 38° 10′ E., off Prince Edward Island; depth, 310 fathoms; bottom, volcanic sand.

Schizopathes conferta, n. sp. | *Cladopathes plumosa*, n. sp.

STATION 160.—March 13, 1874; lat. 42° 42′ S., long. 134° 10′ E., south of Australia; depth, 2600 fathoms; bottom, red clay.

Bathypathes tenuis, n. sp.

STATION 177.—August 18, 1874; lat. 16° 45′ S., long. 168° 7′ E., off Api, New Hebrides; depth, 63 to 130 fathoms; bottom, volcanic sand.

Aphanipathes sarothamnoides, n. sp.

STATION 181.—August 25, 1874; lat. 13° 50′ S., long. 151° 49′ E., south-east of New Guinea; depth, 2440 fathoms; bottom, red clay.

Bathypathes lyra, n. sp.

STATION 192.—September 26, 1874; lat. 5° 49′ 15″ S., long. 132° 14′ 15″ E., off Ki Islands; depth, 140 fathoms; bottom, blue mud.

Aphanipathes cancellata, n. sp. | [*Antipathes*] *cylindrica*, n. sp.

STATION 195.—October 3, 1874; lat. 4° 21′ S., long. 129° 7′ E., off Banda Islands; depth, 1425 fathoms; bottom, blue mud.

Schizopathes affinis, n. sp. | *Bathypathes patula*, n. sp. (young).

STATION 218.—March 1, 1875; lat. 2° 33′ S., long. 144° 4′ E., west of Admiralty Islands; depth, 1070 fathoms; bottom, blue mud.

Schizopathes affinis, n. sp. | *Bathypathes patula*, var. *plenispina*, n. sp.

STATION 244.—June 28, 1875; lat. 35° 22′ N., long. 169° 53′ E., east of Japan; depth, 2900 fathoms; bottom, red clay.

Bathypathes patula, n. sp.

STATION 246.—July 2, 1875; lat. 36° 10′ N., long. 178° 0′ E., east of Japan; depth, 2050 fathoms; bottom, Globigerina ooze.

Bathypathes patula, n. sp. | *Bathypathes alternata*, n. sp.
Bathypathes lyra, n. sp.

STATION 308.—January 5, 1876; lat. 50° 8′ 30″ S., long. 74° 41′ 0″ W., off Tom Bay, Strait of Magellan; depth, 175 fathoms; bottom, blue mud.

Antipathella assimilis, n. sp. | *Antipathella speciosa*, n. sp.
„ *minor*, n. sp. | „ *contorta*, n. sp.

STATION 310.—January 10, 1876; lat. 51° 27′ 30″ S., long. 74° 3′ 0″ W., Sarmiento Channel; depth, 400 fathoms; bottom, blue mud.

Tylopathes crispa, n. sp.

STATION 323.—February 28, 1876; lat. 35° 39′ S., long. 50° 47′ W., off Monte Video; depth, 1900 fathoms; bottom, blue mud.

Schizopathes crassa, n. sp.

STATION 343.—March 27, 1876; lat. 8° 3′ S., long. 14° 27′ W., off Ascension; depth, 425 fathoms; bottom, volcanic sand.

Dendrobrachia fallax, n. sp.

STATION 344.—April 3, 1876; lat. 7° 54′ 20″ S., long. 14° 28′ 20″ W., off Ascension; depth, 420 fathoms; bottom, volcanic sand.

Taxipathes recta, n. sp.

It will be seen from the foregoing list that the whole of the species obtained during the voyage of the Challenger are probably new to science. This is largely accounted for by the fact that the majority of the species were obtained from regions not previously investigated, added to which, six of the species occur at depths from 1070 to 2900 fathoms, whereas no species previously described has been met with at a depth greater than 890 fathoms. The chief areas from which Antipatharia have previously been recorded are the West Indies, the Mediterranean, the Indian Ocean, and the East Indies. The Mediterranean and Indian Ocean proper were not visited by the Challenger, and although Bermuda and St. Thomas were visited, I am not aware that any Antipatharia were obtained there. It is altogether remarkable that no Antipatharia were, so far as I am aware, obtained in the North Atlantic between Stations 1 and 100, although species have previously been obtained near both the east and west shores of the Atlantic, and also off Greenland. Only four of the species come from the East Indies, and two of these belong to a new subfamily (Schizopathinæ). The Pacific Ocean is, on the other hand, represented by ten species, whereas only five species altogether had previously been obtained there, most of them from comparatively shallow water. It is also interesting to note that of the nineteen species of Antipatharia included in the Challenger Collection, eight were obtained south of lat. 40° S.

Our knowledge of the distribution of the Antipatharia is as yet too incomplete to admit of general conclusions being drawn. I have, however, arranged the information at present available in tabular form, in order to facilitate further investigation on the subject. Two species are described of which the habitat is not known; these are *Antipathes pectinata*, Lamk. (sp. incert. sed.), and *Cirripathes paucispina*, n. sp. The remaining ninety-six species have been arranged in eight more or less artificial areas, according to the information obtainable on the subject. The following table shows the divisions adopted, and the number of species recorded from each :—

I. North Atlantic, 10 species.	V. Indian Ocean, 26 species.
II. Mediterranean, 8 „	VI. East Indies, 17 „
III. West Indies, 27 „	VII. North Pacific, 7 „
IV. South Atlantic, 5 „	VIII. South Pacific, 16 „

I. North Atlantic (excluding West Indies and Mediterranean).

Stichopathes gracilis (Gray).	*Pteropathes fragilis*, n. sp.
Antipathes furcata, Gray.	[*Antipathes*] *arctica*, Lütken.
Antipathella gracilis (Gray).	„ *spinescens*, Gray.
„ *boscii* (Lamx.).	„ *squamosa*, Koch.
Aphanipathes wollastoni (Gray MS.).	„ *alopecuroides*, E. and S.

There are at present no Antipatharia recorded from Mid Atlantic. Of those included in the above list, the genera *Stichopathes*, *Antipathes*, *Antipathella*, and *Aphanipathes* occur off Madeira, and one or two species having a bottle-brush type of growth have been found in the Gulf of Guinea. *Antipathella boscii* has been recorded by Lamouroux from South Carolina, and also off the west coast of France. [*Antipathes*] *arctica*, Lütken, is apparently the only species which has been obtained north of lat. 47° N.; it has been obtained on two occasions off the coast of Greenland. The occurrence of *Cirripathes spiralis* (Linn.) off the coast of Norway appears to me very doubtful, and requires confirmation before the species can be admitted into the above list. A new genus (*Pteropathes*) is represented by a single species off St. Paul's Rocks, near the Equator. None of the species included in the above list have as yet been found outside the North Atlantic area.

II. Mediterranean.

Savaglia lamarcki (Haime).
Leiopathes glaberrima (Esp.), M.-Edw.
Antipathes dichotoma, Pall.
„ *fœniculacea*, Pall.
Antipathes mediterranea, n. sp.
? „ *virgata*, Esp.
Antipathella subpinnata (E. and S.).
Parantipathes larix (Esp.).

The occurrence of *Antipathes virgata*, Esp., in the Mediterranean requires confirmation. The species is at present included on the authority of Lamarck, on the supposition that his *Antipathes scoparia* is synonymous with *Antipathes virgata*, Esp. *Antipathes fœniculacea*, Pall., has not, so far as I am aware, been met with by subsequent investigators in the Mediterranean. It is possible that *Antipathes fœniculum*, Lamk., obtained off West Australia during the "Gazelle" Expedition, may not be identical with the type of Pallas. *Leiopathes glaberrima* (Esp.), M.-Edw., occurs in the West Indies as well as in the Mediterranean, and is probably the only Mediterranean species which has been found elsewhere. I am not aware that any unbranched species of Antipathidæ have recently been obtained in the Mediterranean. The occurrence of *Cirripathes spiralis* in this area, cited by Pallas on the authority of Baker, requires confirmation.

III. West Indies.

Stichopathes pourtalesi, n. sp.
„ *occidentalis* (Gray).
„ *desbonni* (D. and M.).
„ *lütkeni*, n. sp.
Leiopathes glaberrima (Esp.), M.-Edw.
„ *lenta* (Pourt.).
Antipathella atlantica (Gray).
„ *gracilis* (Gray).

Antipathella tristis (Duch.).
„ *paniculata* (Duch.).
Aphanipathes pedata (Gray).
„ *thyroides* (Pourt.).
„ *humilis* (Pourt.).
„ *filix* (Pourt.).
„ *barbadensis*, n. sp.
„ *abietina* (Pourt.).
„ *salix* (Pourt.).
„ *eupteridea* (Lamx.).

Parantipathes hirta (Gray).
„ *tetrasticha* (Pourt.).
„ *columnaris* (Duch.).
? „ *larix* (Esp.).
[*Antipathes*] *picea*, Pourt.
„ *tanacetum*, Pourt.
„ *americana*, D. and M.
„ *melancholica*, Duch.
„ *taxiformis*, Duch.

The completeness of the above list is mainly due to the researches of Duchassaing, and to the very complete collections made during the voyages of the "Blake" and "Hassler," which have been described by Pourtalès. The area is particularly rich in species having an obscure type of polyp (associated with elongate spines on the axis), nearly all of which it is now proposed should be referred to the new genus *Aphanipathes*. It is interesting to note that none of the species of this genus, which have the spines longer in the zooidal regions, have as yet been found outside this area. It appears probable that *Parantipathes larix* (Esp.) has been erroneously recorded from the West Indies by Milne-Edwards, Duchassaing, and others. The species was not included amongst the collections of the various United States Exploring Expeditions, nor does it appear clear that the species was actually obtained by Duchassaing. The fact that *Aphanipathes barbadensis*, n. sp., has a type of branching almost indistinguishable at first sight from that of *Parantipathes larix* (Esp.), renders it probable that the two species may have been confused by earlier investigators. *Leiopathes glaberrima* (Esp.), M.-Edw., is the only Old World species which is definitely known to occur in the West Indies. *Antipathella gracilis* (Gray) was recorded from Madeira by Gray, but the only specimen which I have seen is from the West Indies, and Gray's type does not appear to be preserved in the British Museum. All the unbranched species now recorded from this area appear to belong to the genus *Stichopathes;* at any rate none of them have the stouter form of axis prevalent in the genus *Cirripathes*.

IV. South Atlantic.

Stichopathes filiformis (Gray).
Aphanipathes pennacea (Pall.).
Schizopathes crassa, n. sp.
Taxipathes recta, n. sp.
Dendrobrachia fallax, n. sp.

No species of Antipatharia have, so far as I am aware, been previously recorded from the South Atlantic. *Stichopathes filiformis* (Gray) was originally described from

Australia, and has since been obtained off the north-east coast by H.M.S. "Alert." A number of young specimens from St. Helena are preserved in the British Museum. *Aphanipathes pennacea* (Pall.) has been obtained off the same island; it also occurs in the Indian Ocean. The remaining species were obtained during the voyage of the Challenger,—*Schizopathes crassa*, off Monte Video; *Taxipathes recta* and *Dendrobrachia fallax*, off Ascension.

V. Indian Ocean (including Red Sea).

Cirripathes spiralis (Linn.), Blainv.
,, *diversa*, n. sp.
,, *flagellum*, n. sp.
,, *anguina*, Dana.
Stichopathes echinulata, n. sp.
Antipathes fœniculacea, Pall.
,, *virgata*, Esp.
,, *lentipinna*, n. sp.
Aphanipathes alata, n. sp.
,, *verticillata*, n. sp.
Tylopathes flabellum (Pall.).
,, *hypnoides*, n. sp.
,, *elegans*, n. sp.
Arachnopathes ericoides (Pall.), M.-Edw.
,, *clathrata* (Pall.), M.-Edw.
[*Antipathes*] *corticata*, Lamk.
,, *abies* (Linn.), Gray.
,, *pumila*, n. sp.
,, *ulex*, E. and S.
,, *spinosa* (Carter).
,, *myriophylla*, Pall.
,, *lacerata*, Lamk.
,, *isidis-plocamos*, Klunz.
Schizopathes conferta, n. sp.
Bathypathes tenuis, n. sp.
Cladopathes plumosa, n. sp.

The species described by earlier authors from the Indian Ocean have rarely had a definite habitat assigned to them; indeed, in many cases the type specimens were purchased from dealers in Europe. The following lists have been compiled from various sources :—

Red Sea.—*Cirripathes anguina*, Dana; *Antipathes lentipinna*, n. sp.; [*Antipathes*] *corticata*, Lamk.; [*Antipathes*] *isidis-plocamos*, Klunz.

Persian Gulf.—*Antipathes virgata*, Esp.

Off Kurrachee.—*Cirripathes spiralis* (Linn.), Blainv.; *Tylopathes elegans*, n. sp. [*Antipathes*] *pumila*, n. sp.

Off Ceylon.—*Cirripathes spiralis* (Linn.), Blainv.; *Cirripathes anguina*, Dana; *Cirripathes diversa*, n. sp.; *Cirripathes flagellum*, n. sp.; [*Antipathes*] *abies* (Linn.), Gray; [*Antipathes*] *abies*, var. *paniculata*, Esp.; [*Antipathes*] *spinosa* (Carter).

Off Seychelles Islands.—*Cirripathes anguina*, Dana.

Off Mauritius.—*Stichopathes echinulata*, n. sp.; *Aphanipathes verticillata*, n. sp.;

Aphanipathes alata, n. sp.; *Tylopathes hypnoides*, n. sp.; [*Antipathes*] *abies* (Linn.), Gray.

Off Madagascar.—*Tylopathes flabellum* (Pall.).

Off West Australia.—*Antipathes fœniculacea*, Pall. (*Antipathes fœniculum*, Lamk.).

The following three species of Schizopathinæ were obtained by the Challenger south of lat. 40° S.:—*Schizopathes conferta*, n. sp.; *Bathypathes tenuis*, n. sp.; *Cladopathes plumosa*, n. sp.

None of the species at present referred to the genus *Antipathella* have as yet been observed in the Indian Ocean, though those from this area which are provisionally included in the genus *Tylopathes* have a similar type of spine, but their polyps have not been observed.

VI. East Indies.

Cirripathes anguina, Dana.
„ *spiralis* (Linn.), Blainv.
Antipathes virgata, Esp.
Antipathella reticulata (Esp.).
Aphanipathes cancellata, n. sp.
„ *pennacea* (Pall.).
Tylopathes flabellum (Pall.).
Schizopathes affinis, n. sp.
Bathypathes patula, n. sp. (young).
Arachnopathes aculeata, n. sp.
[*Antipathes*] *cylindrica*, n. sp.
„ *corticata*, Lamk.
„ *abies* (Linn.), Gray.
„ *bifaria*, n. sp.
„ *ulex*, E. and S.
„ *myriophylla*, Pall.
[*Antipathes*] *triquetra*, Brug.

The fauna of this area may be divided into two sections, the one including Formosa and the Philippines, the other the seas between Sumatra and New Guinea.

1. Lat. 5°–25° N.—*Antipathella reticulata* (Esp.); [*Antipathes*] *abies* (Linn.), Gray; [*Antipathes*] *ulex*, E. and S.; [*Antipathes*] *myriophylla*, Pall.; [*Antipathes*] *bifaria*, n. sp.; [*Antipathes*] *triquetra*, Brug.
2. Lat. 0°–10° S.—*Cirripathes anguina*, Dana; *Cirripathes spiralis* (Linn.), Blainv.; *Aphanipathes cancellata*, n. sp.; *Schizopathes affinis*, n. sp.. *Bathypathes patula*, n. sp. (young); *Arachnopathes aculeata*, n. sp.; [*Antipathes*] *cylindrica*, n. sp.; [*Antipathes*] *abies* (Linn.), Gray, and var. *paniculata*, Esper; [*Antipathes*] *myriophylla*, Pall.; [*Antipathes*] *ulex*, E. and S.

Both species of Schizopathinæ have also been obtained in the Pacific.

VII. North Pacific.

Antipathella intermedia, n. sp.
Tylopathes dubia, n. sp.
Bathypathes patula, n. sp.
Bathypathes alternata, n. sp.
,, *lyra*, n. sp.
[*Antipathes*] *panamensis*, Verrill.
[*Antipathes*] *japonica*, n. sp.

The three species of the genus *Bathypathes* were obtained in Mid Pacific during the voyage of the Challenger. All the other species, with the exception of [*Antipathes*] *panamensis*, Verrill, have been collected off the coasts of Japan.

VIII. South Pacific.

Cirripathes propinqua, n. sp.
,, *anguina*, Dana.
Stichopathes filiformis (Gray).
Antipathes arborea, Dana.
Antipathella assimilis, n. sp.
,, *minor*, n. sp.
,, *speciosa*, n. sp.
,, *contorta*, n. sp.
Antipathella strigosa, n. sp.
Aphanipathes sarothamnoides, n. sp.
,, *fruticosa* (Gray).
Tylopathes crispa, n. sp.
Parantipathes fernandezi (Pourt.).
Schizopathes affinis, n. sp.
Bathypathes patula, n. sp., var. *plenispina*, nov.
Bathypathes lyra, n. sp.

Schizopathes affinis, n. sp., and *Bathypathes patula*, n. sp., var. *plenispina*, occur off the Admiralty Islands, and the following between New Guinea and Fiji:—*Cirripathes propinqua*, n. sp.; *Cirripathes anguina*, Dana; *Stichopathes filiformis* (Gray); *Antipathes arborea*, Dana; *Aphanipathes sarothamnoides*, n. sp.; *Schizopathes affinis*, n. sp.; and *Bathypathes lyra*, n. sp. *Parantipathes fernandezi* (Pourt.) has been obtained off Juan Fernandez.

Six of the species in the above list have been obtained south of lat. 40° S. These are:—*Antipathella assimilis*, n. sp.; *Antipathella minor*, n. sp.; *Antipathella speciosa*, n. sp.; *Antipathella contorta*, n. sp.; and *Tylopathes crispa*, n. sp., in or near the Strait of Magellan, and *Aphanipathes fruticosa* (Gray) off Stephens Island, New Zealand.

BATHYMETRICAL RANGE.

Little information is available regarding the bathymetrical range of the Antipatharia generally, and Pourtalès is the principal investigator who has devoted attention to the subject; I have only been able to obtain information as to the depth at which fifty-three species occur—just about half the number described. These may be grouped according to the depths at which they were collected as follows :—

Zone.	Fathoms.	Species.
I.	0 to 10	6
II.	10 „ 100	25
III.	100 „ 500	26
IV.	500 „ 1000	2
V.	1000 „ 2000	3
VI.	2000 „ 3000	4

It is probable that all or nearly all of the 45 species not included in the above list have been obtained at depths under 100 fathoms. The greatest depth at which Antipatharia have previously been recorded is 878 fathoms in the Caribbean Sea.

Bathymetrical Range of the Genera of Antipathidæ.

Antipathinæ—

Cirripathes, 1 to 4 fathoms (information available for two species only).
Stichopathes, 10 to 878 fathoms.
Leiopathes, 35 to 324 fathoms.
Antipathes, 10 to 140 fathoms.
Antipathella, 33 to 226 fathoms.
Aphanipathes, 76 to 287 fathoms.
Tylopathes, 400 fathoms.

Antipathinæ—*continued.*

Pteropathes, 10 to 80 fathoms.
Parantipathes, 54 to 861 fathoms.

Schizopathinæ—

Schizopathes, 310 to 1900 fathoms.
Bathypathes, 1070 to 2900 fathoms.
Taxipathes, 420 fathoms.
Cladopathes, 310 fathoms.

TABLE SHOWING THE BATHYMETRICAL RANGE OF ALL THE SPECIES OF ANTIPATHARIA, SO FAR AS KNOWN.

	I. 0–10 Fathoms.	II. 10–100 Fathoms.	III. 100–500 Fathoms.	IV. 500–1000 Fathoms.	V. 1000–2000 Fathoms.	VI. 2000–3000 Fathoms.
ANTIPATHINÆ—						
Cirripathes propinqua, n. sp.,	×					
„ *anguina*, Dana,	×					
Stichopathes pourtalesi, n. sp.,		×	×	×		
„ *filiformis* (Gray),	×					
„ *desbonni* (D. and M.),		×				
Leiopathes glaberrima (Esp.), M.-Edw.,			×			
„ *lenta* (Pourt.),		×				
Antipathes dichotoma, Pall.,			×			
„ *arborea*, Dana,	×					
„ *fœniculacea*, Pall.,		×				
„ *mediterranea*, n. sp.,		×				
Antipathella subpinnata (E. and S.),			×			
„ *assimilis*, n. sp.,			×			
„ *speciosa*, n. sp.,			×			
„ *minor*, n. sp.,			×			
„ *contorta*, n. sp.,			×			
„ *tristis* (Duch.),		×	×			
„ *paniculata* (Duch.),		×				
Aphanipathes sarothamnoides, n. sp.,		×	×			
„ *cancellata*, n. sp.,			×			
„ *thyroides* (Pourt.),			×			
„ *humilis* (Pourt.),		×	×			
„ *filix* (Pourt.),		×	×			
„ *abietina* (Pourt.),		×				
„ *salix* (Pourt.),			×			
„ *eupteridea* (Lamx.),		×				
Tylopathes crispa, n. sp.,			×			
Pteropathes fragilis, n. sp.,		×				
Parantipathes larix (Esp.),		×				
„ *tetrasticha* (Pourt.),			×			
„ *fernandezi* (Pourt.),		×	×			
„ *columnaris* (Duch.),		×	×	×		
SCHIZOPATHINÆ—						
Schizopathes crassa, n. sp.,					×	
„ *affinis*, n. sp.,					×	
„ *conferta*, n. sp.,			×			
Taxipathes recta, n. sp.,			×			
Bathypathes patula, n. sp.,						×
„ „ young,					×	
„ „ var. *plenispina*,					×	
„ *alternata*, n. sp.,						×
„ *tenuis*, n. sp.,						×
„ *lyra*, n. sp.,						×
Cladopathes plumosa, n. sp.,			×			

TABLE SHOWING THE BATHYMETRICAL RANGE OF ALL THE SPECIES OF ANTIPATHARIA, SO FAR AS KNOWN—*continued.*

	I. 0–10 Fathoms.	II. 10–100 Fathoms.	III. 100–500 Fathoms.	IV. 500–1000 Fathoms.	V. 1000–2000 Fathoms.	VI. 2000–3000 Fathoms.
DENDROBRACHIIDÆ—						
Dendrobrachia fallax, n. sp.,			×			
SAVAGLIIDÆ—						
Savaglia lamarcki (Haime),		?				
SPECIES INCERTÆ SEDIS, &c.—						
[*Antipathes*] *picea*, Pourt.,	×	×	×			
„ *tanacetum*, Pourt.,		×	×			
„ *cylindrica*, n. sp.,			×			
„ *panamensis*, Verrill,	×					
„ *ulex*, E. and S.,		×				
„ *spinosa* (Carter),		×				
„ *abies* (Linn.), Gray,		×				
„ *taxiformis*, Duch.,		×				
„ *melancholica*, Duch.,		×				
„ *americana*, D. and M.,		×				

The foregoing tables bring out several points of considerable interest. Perhaps one of the most important is the fact that no species belonging to the subfamily Antipathinæ are known to occur at depths exceeding 900 fathoms. Indeed, only two species are known which extend beyond the continental zone; both occur in the Caribbean Sea, and extend from the littoral zone into deep water. *Stichopathes pourtalesi* is perhaps the most abundant species in the West Indies, and has a wide range—45 to 878 fathoms. *Parantipathes columnaris* (Duch.) is also frequent in the same area, and extends from 73 to 861 fathoms. With these two exceptions the bathymetrical range of the Antipathinæ is from 5 feet to 400 fathoms. The Schizopathinæ, on the other hand, are chiefly abyssal forms, but a few species occur at depths between 300 and 500 fathoms. An interesting comparison may be instituted between the form and thickness of the corallum in various Schizopathinæ, and the depths at which the respective species occur. In *Schizopathes crassa* (1900 fathoms) and *Schizopathes affinis* (1070 and 1428 fathoms), the stem is slender and bears two rows of elongate slender branches. In *Schizopathes conferta*, obtained off Prince Edward Island in 310 fathoms, the stem and branches are much thicker and more densely clothed with spines. Four species of *Bathypathes* are described, the types of which

were all obtained in depths of over 2000 fathoms. In this genus the corallum is smaller and more delicate than in any other Schizopathinæ. In the case of *Bathypathes patula*, which was probably obtained at four stations, it is important to note that typical specimens were obtained only in 2050 and 2900 fathoms in the deep water west of Japan. Two specimens, which appear to be *immature* forms, were obtained in 1428 fathoms off the Banda Islands, whilst the var. *plenispina* occurs in still shallower water, off the Admiralty Islands in 1070 fathoms. This form has a proportionately stronger stem than the type, and the spines are both larger and much more numerous. The species has evidently a very wide bathymetrical range, practically from 1000 to 3000 fathoms. The genera *Cladopathes* and *Taxipathes* differ in several important respects from other Schizopathinæ, and in the form of corallum approach closely that of certain Antipathinæ. In both genera the corallum is strong and much branched, and the dimorphic zooids, in *Cladopathes* at any rate, are not so completely separated as in other forms. *Cladopathes plumosa* has been obtained in 310 fathoms, *Taxipathes recta* in 420 fathoms. It would be almost impossible to decide that either species belonged to the Schizopathinæ from an examination of the skeletal characters alone. It thus appears that in the Schizopathinæ a considerable increase in depth is associated with a simplification in the type of corallum and a greater isolation of the dimorphic zooids.

A further point which should be mentioned is, that only two species of Antipatharia are at present known from depths between 500 and 1000 fathoms, although seven species have been obtained at greater depths. It is a curious fact that none of the Challenger species have been dredged within those limits.

ANATOMY OF THE ANTIPATHINÆ.

In the limited time at my disposal it has not been possible to prepare an account of the structure of the whole of the genera and species of Antipathidæ examined, and the following remarks are offered as a preliminary contribution to the subject. Owing to the length of time which has elapsed since the Challenger Collection was made, many of the specimens preserved in strong spirit do not show histological details satisfactorily, added to which, the small size of the polyps of most species makes them difficult of manipulation. I have on these accounts been unable to avail myself of the methods of maceration, &c., which yielded such excellent results in the hands of the brothers Hertwig when studying the histology of the Actiniaria.

The histological structure of the Antipathinæ is in its main features similar to that of Actiniaria, but in this respect there is a closer approach to the condition found in Zoanthidæ and Cerianthidæ than to the Hexactiniæ. Two features are of special interest, viz., the extremely rudimentary condition of the muscular system and the thin homogeneous mesoglœa, which is apparently entirely devoid of stellate connective tissue cells. These have, however, been observed in *Cladopathes* amongst the Schizopathinæ, in which genus the mesoglœa is thicker than in any other observed, and approaches more closely to the Hexactinian type.

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Antipathella subpinnata.

The polyps of this species are subregular in size, but occasionally near the apex of a pinnule small and immature individuals are to be observed (*cf.* Pl. XIII. fig. 3). The average length of a polyp in the sagittal axis is 1 mm., and about 0·5 mm. in the transverse axis. The elongation in the transverse axis is frequently most marked in young individuals. The tentacles in spirit specimens are subcylindrical with a dilated base; they may be 0·6 mm. long. The space between the tentacles is occupied by a large rounded prominence, on which the mouth opens. The oral aperture is usually much elongated and slit-like. In certain cases, where the mouth is preserved widely open (Pl. XIII. fig. 4), it forms a large, circular, shallow pit, exposing the elongate stomodæum below, and has a diameter corresponding with that of the oral prominence itself. The outer margin is circular, but the inner one is crenate, each depression corresponding with the insertion of a mesentery. The zooidal tissues consist of a relatively thick ectoderm, a thin and apparently homogeneous mesoglœa, and a glandular entoderm of variable thickness. The polyps are incompletely separated from one another by plate-like mesoglœal septa, clothed on each side with entoderm. In sections parallel to the axis of a pinnule, but which do not pass through the sclerobasic axis and its surrounding tissue (Pl. XIII. fig. 5), the septa are seen to pass straight across from the mesoglœa of the zooidal surface to that beneath. In mesial sections, however, the septa are seen to cease above the circumaxial tissue, and a series of transverse sections of a pinnule in the interzooidal regions shows that each septum has a somewhat circular aperture near its base, through which the sclerenchyma and the tissue surrounding it pass. As the septa are not fused with the circumaxial tissue, the cœlentera of adjoining polyps are in communication with one another at this point. The stomodæum is much elongated in the sagittal axis of the polyp and has a slit-like lumen. It consists of a flattened, straight or slightly-folded, tube, which reaches to within a short distance of the circumaxial tissue (*cf.* Pl. XIII. figs. 5, 6, and 7). In sagittal sections (Pl. XIII. fig. 6) it extends to a point on a level with the insertion of the sagittal tentacles, and the free border is usually somewhat thickened. In sections parallel with the long (transverse) axis of a polyp, the inner margin of the stomodæum is seen to take a sharp bend outwards, and, after a short subhorizontal course, it ultimately fuses with the transverse mesenteries. The structure and arrangement of the mesenteries is best studied from a series of horizontal sections, commencing at the surface of the oral cone. A little

distance beneath the surface such sections show ten mesenteries, arranged in a similar manner to those of *Cirripathes propinqua* (*cf.* fig. 4, p. 39). Each mesentery consists of a thin layer of mesoglœa, clothed on each side by entoderm. The mesoglœa of the stomodæum is thus united to that of the oral cone by ten slender partitions, and the interseptal chambers thus formed are lined by entoderm. The interseptal chambers are at first very small, and those at each end of the long axis of the stomodæum remain slit-like for a considerable distance. The "directive" mesenteries are very narrow for their whole course (*cf.* Pl. XIII. fig. 7); beneath the stomodæum they are attached to the body-wall for a very short distance, and have a slightly thickened border. The transverse pair of mesenteries increase in breadth in the lower part of the oral cone, and beneath it rapidly extend to the lateral extremities of the polyp. In their lower section these mesenteries are much thickened and bear the sexual elements. The greater part of the lateral sections of the cœlenteron is occupied by the transverse mesenteries and by the convoluted filaments to which they give rise. They are the longest and most important of all the mesenteries, and their filaments practically fill up the whole of the space beneath the stomodæum. The two pairs of secondary mesenteries, situated one on each side of the transverse mesenteries, are never important, and become lost before the base of the stomodæum is reached. In the subhorizontal section figured (Pl. XIII. fig. 7), the member of each secondary pair which is situated above the stomodæum extends from the stomodæum to the body-wall. On the opposite side of the stomodæum the right hand mesentery is seen to have lost its connection with the body-wall, but remains as a projection from the stomodæum. That on the left hand has disappeared above the level of the section in that part. The secondary mesenteries do not bear filaments, nor is their free margin thickened, as in the case of the "directive" mesenteries. The appearance and situation of the mesenterial filaments will be understood by a reference to the figures already cited; their structure will be described later. The relation of a polyp to the sclerenchyma, which serves as its support, is best studied in sagittal sections showing the sclerenchyma in transverse section. Pl. XIII. fig. 6 represents a section passing through the extreme elongation of the stomodæum, and shows the insertion of the sagittal tentacles. Beneath the stomodæum the section passes through two mesenterial filaments, and still lower, quite at the base of the cœlenteron, a rounded mass of tissue is seen, containing a central lumen, within which the sclerenchyma is situated. The sclerenchymatous sheath consists externally of a comparatively thick and irregular layer of entoderm, beneath which is a thin layer of mesoglœa. Its inner surface is clothed by a thin and irregular epithelium, which constitutes the secretory layer. The sclerenchyma consists of a large number of very thin, concentric, horny lamellæ, arranged around a comparatively large central lumen. The mesoglœa of the sclerenchymatous sheath is united to that of the base (cœnenchyma) by means of a short septum (Pl. XIII. fig. 6, sep.'), which runs the whole length of a branch.

Ectoderm.—In the Hexactiniæ the ectoderm is divided by O. and R. Hertwig into three layers: (1) a comparatively thick epithelial layer; (2) a nervous layer, which is rendered granular by the action of most reagents; and (3) a thin muscular layer, applied to the outer surface of the mesoglœa. The epithelial layer contains four kinds of cells, viz.:—Nematocysts, glandular cells, ciliated epithelial cells (Stützzellen), and sensory cells. The two latter types call for a word of explanation. The ciliated epithelial cells are narrow and band-like, with a dilation at each extremity, but the peripheral end is wider; they bear numerous cilia, and generally extend from the surface of the ectoderm to the muscular layer. The sensory cells are extremely fine and thread-like, with a dilation containing the nucleus about the middle or near the base of the cell. They bear at the apex a single delicate flagellum, and the base passes into numerous fine fibrillæ, which are connected with a nerve plexus. Ganglion cells with large nuclei are generally recognisable in the nervous layer. The sensory cells are distributed with a considerable degree of uniformity between the other cellular elements of the ectoderm, but owing to their extreme delicacy little information concerning them can be gathered from sections, and it is necessary to separate the sensory cells and ciliated "Stützzellen" by maceration, &c., before their outlines can be made out.

The ectoderm of *Antipathella subpinnata*, as might be expected, is not so complex as that of Hexactiniæ, but it appears probable that it has a similar general structure. The ectoderm of the tentacles is very thick, and its surface is raised into a large number of transverse oval ridges, which vary from 85 × 45 μ to 48 × 22 μ in diameter. In longitudinal sections of a tentacle these ridges appear as gentle crenations of the surface, which become lost towards the apex of the tentacle. Most prominent amongst the histological elements of the layer are a number of clusters of large hyaline cells, which extend from the surface to the base of the ectoderm (Pl. XIII. fig. 8, *g'*). These are probably gland cells, and may serve to secrete mucus. They remain quite transparent in sections stained with borax-carmine, and the outline of the individual cells is not well defined. Each cell has a small round nucleus near its base. Near the middle of each group three or four more deeply-stained lines may often be noticed at moderate intervals, which appear to commence at a little distance beneath the surface, and to reach nearly to the base. The middle of each line bears an oval thickening, which is also deeply stained. Bearing in mind the inter-relationship of the various types of cells in the ectoderm of Actiniaria, it appears probable that the deeply-stained lines with a median thickening represent thread-like nucleated sensory cells, which are interposed between the gland cells. In specimens stained with hæmatoxylin, the hyaline cells stain darker than the bundles of nematocysts, but no further structure is shown, the stain being apparently confined to the cell-wall and the nucleus. Each group appears to consist of rather slender elongate cells, having a dilation at the surface of the layer. Sometimes the distal portion of a cell is triangular in section. These hyaline gland cells are from 10 to 60 μ long, and vary

from 1·3 to 11 μ in breadth. Between the clusters of hyaline cells, and only rarely occupying the most prominent part of a ridge, bundles or batteries of nematocysts occur, which are usually arranged in well-defined groups. The nematocysts are slender spindle-shaped cells varying from 14·9 to 16·7 μ in length, and about 2 μ in diameter. They extend from the surface to about the middle of the ectoderm; those forming one battery may be subparallel, or their distal ends may be closely pressed together so as to form a fan-shaped group. Extremely delicate fibres may frequently be distinguished between the nematocysts, which probably reach the surface, but this is difficult to make out in sections. Beneath the nematocysts the fibrous cells are seen to be more numerous; each contains a round or oval nucleus, which stains deeply. On this account the ectoderm appears in sections to be divided into alternate dark and light areas, the former corresponding to the nematocysts and the nucleated fibres, which extend beneath them to the base of the layer. The nematocysts are most numerous near the apex of a tentacle, where only one or two hyaline cells are interposed between each group. Lower down the nematocysts are more distinctly collected into batteries. In this species the hyaline cells usually project somewhat beyond the batteries of nematocysts, and so form the most prominent part of the ectoderm. Towards the middle of the body-wall the elevated ridges become lost, and the batteries of nematocysts are considerably larger. The deeply-stained nuclei beneath them are numerous, round or elongate, and are frequently pressed in between the nematocysts. It appears probable that these may represent young nematocysts in the process of differentiation. Some of them show a division of the chromatin into transverse bands. The formation of new nematocysts in such a position has already been observed by Jourdan in Actiniaria.

The ectoderm of the peristome and oral cone is not papillose, but has a similar thickness to that of the tentacles. The batteries of nematocysts are here smaller and more distant. Between them, and apparently connected with the hyaline gland cells, a number of sensory threads occur, which are connected with nucleated ganglia situated near the base of the ectoderm. Similar ganglia have not been observed in the ectoderm of the tentacles, but it is probable that they may have been overlooked. So far as could be ascertained the arrangement of the nervous elements is similar to that of Actiniaria, but it is desirable that this point should be studied further from specially prepared material.

Towards the base of a polyp the ectoderm becomes gradually reduced in thickness, and its surface is quite smooth. The tendency of the nematocysts and hyaline gland cells to become collected into alternate groups, which is so well marked in the tentacles and upper portion of the body-wall, is here scarcely noticeable, and the appearance presented is therefore more readily comparable with the usual condition in Actiniaria.

The ectodermal muscular system of *Antipathella subpinnata* appears to be extremely rudimentary, indeed, I have rarely recognised any appearance which might

indicate the presence of ectodermal muscular fibres in this species. In some cases, in transverse vertical sections stained in borax-carmine, I have noticed at the base of the ectoderm of the body-wall what appear to be a few slender muscular fibres cut rather obliquely, but the point requires further study. It is interesting to note that this is precisely that part of the ectoderm which does not contain a muscular layer in Actiniaria according to the brothers Hertwig. Such a layer is undoubtedly present in the ectoderm of the body-wall of *Antipathes dichotoma* (*cf.* Pl. XIV. fig. 6, *f*), and other forms, and may therefore be presumed to have a greater or less development in *Antipathella*.

I have failed to recognise any ciliated epithelial cells (Stützzellen) in the external ectoderm of *Antipathella subpinnata*, but such cells appear to be present in the ectoderm of the stomodæum, although they are not recognisable in borax-carmine preparations. The surface of the ectoderm is probably ciliated, but it is difficult to study such points in specimens which have been preserved for a long time in strong spirit.

Stomodæum.—In Actiniaria the ectoderm of the stomodæum has a similar general structure to that of the peristome, but the muscular layer is absent. The epithelial layer is of considerable thickness, but is only one-layered, and contains "Stützzellen," nematocysts, and two kinds of gland cells. The nervous layer is readily recognised, but the ganglia are not numerous. The stomodæum of *Antipathella subpinnata* presents an interesting structure, and differs in one or two important points from that of Actiniaria. In the first place, nematocysts are entirely, or almost entirely, absent. The stomodæum of Antipathinæ may readily be distinguished from the ectoderm of the external surface, on account of the fact that it stains more deeply with borax-carmine or hæmatoxylin than any other portion of a section, with the exception of the free margins of the mesenterial filaments. The ectoderm consists here chiefly of two kinds of glandular cells, the one hyaline, the other densely stained. In borax-carmine preparations (Pl. XIII. fig. 10) the greater part of the layer is seen to be occupied by large oval hyaline gland cells, each with a deeply-stained nucleus. They rest on a delicate layer of nerve-fibres adjoining the mesoglœa, and fill up the lower half or two-thirds of the epithelial layer. The cell plasma does not stain, but here and there indications of a semigranular coagulum may be noticed. Thread-like cells are placed between the large gland cells, as in the ectoderm of the tentacles and body-wall, but are not so easily seen. The hyaline cells are similar to those in the epithelial layer of the tentacles, but are broader, and do not usually reach the surface. The surface of the ectoderm in this region is apparently occupied by a large number of small lens-shaped cells, which stain very deeply in borax-carmine; some of them belong to a second and smaller type of gland cell filled with granules. In many cases wedge-shaped clusters of these small and deeply-stained cells extend for some distance

between the distal ends of the hyaline gland cells, and sometimes nearly reach to the base of the layer. The outline of the individual cells is, however, not well defined in borax-carmine preparations. In sections stained with hæmatoxylin the appearance is quite different, and some of the small granular gland cells are well defined. In such cases the structure of the stomodæal ectoderm closely resembles that of Actiniaria, excepting for the apparent absence of nematocysts. The surface of the stomodæum is composed of slender, ribbon-like, ciliated cells, usually separated from one another by delicate, thread-like, sensory cells. The nuclei of both these types of cells are situated about the middle of the layer, and on account of their great affinity for the stain, appear as an irregular dark band across the middle of the ectoderm. Just beneath the surface numerous small oval gland cells are pushed in between the ciliated "Stützzellen" at irregular intervals. These vary from 8·75 to 10·3 μ in length, and from 3·2 to 6·75 μ in breadth. They stain deeply in hæmatoxylin, and are seen to be filled with comparatively large rounded granules. On this account this type of cell will be distinguished as the granular gland cells. The granular gland cells appear to be connected by a delicate stalk or fibre to the base of the ectoderm. Between the proximal ends of the non-glandular cells, large, oval, hyaline gland cells occur in considerable numbers, forming the chief feature of the lower portion of the epithelial layer of the ectoderm, and resting directly on the nervous layer. The hyaline gland cells vary from 24·3 to 37·5 μ in length, and from 10·7 to 12·5 μ in breadth. No ectodermal muscular fibres have been observed in the stomodæum.

Mesoglœa.—The mesoglœa in Actiniaria consists of a moderately thick layer, presenting a uniform ground substance in which numerous fibres are distributed. In Hexactiniæ the layer also includes numerous stellate or spindle-shaped connective-tissue cells, but these are either absent altogether or much reduced in importance in Cerianthidæ and Zoanthidæ. In the Antipathinæ the mesoglœa is usually very thin, and does not contain any stellate or spindle-shaped connective-tissue cells. In *Antipathella subpinnata* this layer has an average thickness of 3 μ in the tentacles, and does not attain a greater thickness than 9 μ in any part of the polyp. It usually appears structureless in section, but sometimes irregular longitudinal lines may be recognised within its substance. These may indicate the presence of fibres, or may, perhaps, be due to the action of hardening reagents. In any case such striations do not appear to be always present.

Entoderm.—In Actiniaria the entoderm consists largely of a layer of cylindrical epithelial cells in which symbiotic Algæ are frequently imbedded. Each epithelial cell is intimately connected at its base with a slender muscular filament. A few nematocysts are also present, and also a variable supply of hyaline and granular gland cells. Whilst a distinct nervous layer is not always demonstrable, the whole of the epithelial cells appear to end basalwards in muscular or nervous threads, and thus constitute more

primitive myo- and neuro-epithelia, not so fully differentiated as in the ectoderm. In the Antipathinæ the entoderm has a structure which comes closer to that of Cerianthidæ than to the condition found in Hexactiniæ. This is due to the fact that in Antipathinæ the gland cells are numerous, and usually regularly distributed in all parts of the entoderm.

In *Antipathella subpinnata* the entoderm varies considerably in thickness in different parts of the polyp. That of the tentacles has a diameter of 14 to 21 μ; in portions of the body-wall the layer attains a thickness of 32 μ or more. The entoderm is everywhere chiefly composed of hyaline gland cells, which remain quite transparent in borax-carmine preparations, but in hæmatoxylin the cell-wall stains slightly. Each cell contains a single deeply-stained nucleus, sometimes placed near the centre, at others near the base. The gland cells vary considerably in shape. Many are subtriangular with one side resting on the base of the layer; others are broadly oval, whilst others again are more elongate and slender. They vary from 9 to 20 μ in length, and from 4 to 10 μ in breadth. The appearance of the entoderm in the tentacles (when stained in borax-carmine) is shown in Pl. XIII. fig. 8, *en;* that of the stomodæum, under similar conditions, in Pl. XIII. fig. 10, *en.* In both cases, adjoining the mesoglœa, a thin, granular, or semifibrous layer occurs, in which the bases of the gland cells are imbedded. This probably represents the nervous layer of Actiniaria. Ganglion cells have occasionally been observed at its base; one of these is represented about the middle of the entodermal nervous layer in Pl. XIII. fig. 10. Between the hyaline gland cells a number of elongate fibrous cells occur, the course of which is difficult to follow, but they appear to reach the surface of the layer and contain large round or oval nuclei. The hyaline gland cells are frequently so elongate as to reach the surface of the entoderm, or are only separated from it by an irregular layer of cubical cells, each with a large nucleus. In other cases, however, where the gland cells are not so elongate, the surface of the entoderm is occupied by a number of short, ribbon-like, ciliated epithelial cells, which appear to taper below and to be pushed in between the glandular elements. These cells are not well defined in either hæmatoxylin or borax-carmine preparations. The gland cells are practically all of the hyaline type, but a small isolated granular gland cell has occasionally been noticed having a similar position and structure to those of the stomodæal ectoderm. No nematocysts have been observed in the entoderm. The entodermal muscular system appears to be extremely rudimentary, but a few circular fibres appear to be present in certain parts; in the greater portion of the layer it appears more probable that the myo-epithelial cells have not given rise to a definite layer of muscular fibres. Borax-carmine does not appear to bring out the muscular fibres clearly; they have been seen most distinctly in transverse vertical sections of the stomodæum stained in hæmatoxylin.

Ova.—The ova are contained within dilations of the transverse mesenteries, the

entoderm of which is considerably thickened. A horizontal section of one of the transverse mesenteries is shown in Pl. XV. fig. 2, which includes the whole breadth of the mesentery. The upper oblique band of mesoglœa is that of the stomodæum; that below forms part of the body-wall. The mesoglœa of the mesentery does not appear to consist here of the usual simple band, but towards the middle the band proceeding from each extremity becomes broken up into a number of fibres, the limits of which could not be observed. It appears clear, however, that the youngest ova are found in the central portion of the mesentery adjoining the mesoglœal fibres. The germinal cells appear to be derived from the entoderm, and various stages in their development are indicated in the figure already referred to. As the ova increase in size they appear to approach the surface of the entoderm. The tissue surrounding each of the large ova is fibrous, but no definite mesoglœal capsule has been observed around them as in the case of *Antipathella contorta*.

Mesenterial filaments.—The majority of the specimens contain a few elongate and simple ribbon-like mesenterial filaments about 0·7 mm. long, which reach halfway across the cœlenteron in transverse vertical sections. Each consists of a median band of mesoglœa, on both sides of which a layer of entoderm occurs (*cf.* Pl. XIII. fig. 5). The free margin on the other hand consists of a rounded cap of cells derived from the stomodæal ectoderm. Other filaments are convoluted and branched. Occasionally one of the short branches bears two lateral dilations which consist of entoderm cells. Such lateral lobes have, however, been rarely observed, and certainly do not appear constant. I am uncertain whether they should be regarded as homologous with the "Flimmerstreifen" of the Actiniaria, or as accidental products due to the subdivision of a filament near its apex.

Parasites.—An interesting vermiform parasite has been met with on two occasions in serial sagittal sections of *Antipathella subpinnata*. Unfortunately I am unable to give a full description or suggest the affinities of the form in question, as my sections do not include a whole individual in either case. The parasite is usually situated in the lower part of the cœlenteron between the base of the mesenteries, the body-wall, and the skeletal sheath, and is usually confined to one side of the lumen. In cases where it is in contact with the zooidal tissues the entoderm is considerably reduced. The parasite occupies that part of the cœlenteron which is usually filled with mesenterial filaments. In both cases where the parasite is present the mesenterial filaments form a convoluted mass pushed up into the lumen of the stomodæum, and one or two of the filaments project freely beyond the mouth. This abnormality is probably due to the presence of the parasite, and has not been observed in any other instances. One specimen has been traced through 200 consecutive sections (= circa 1·2 mm.), which include sections through two zooids and two interzooidal areas (cœnenchyma). In the interzooidal areas the parasite completely fills the stolon-like lumen of the cœlenteron.

The only part of which sections were obtained consists of an elongate reproductive capsule, having a flattened oval outline about 0·23 × 0·14 mm. in diameter. At irregular intervals a short blunt lobe is pushed out from one side or the other, and distinct indications of an annular constriction have been noticed in one specimen. The structure is similar in all the sections examined. The wall of the capsule (Pl. XV. fig. 6) consists of fibrous tissue in which a large number of small oval germinal cells are imbedded. More internally the germinal cells are collected into groups of variable size, still supported by a fibrous stroma, and show various stages of subdivision. Apparently each germinal cell gives rise to a cluster of spermatozoa in most instances (Pl. XV. fig. 6, *l*), but in one of the specimens ova have also been observed. The ova are small and contain a relatively large nucleus with a central large nucleolus and a number of small ones distributed around the periphery.

A small infusoriform parasite has also been met with on several occasions, both associated with the larger vermiform one and in other specimens. It is pear-shaped or oval in outline, and usually contains a large circular hyaline area together with a number of densely stained masses, which are irregularly distributed through the protoplasm. In some of the sections of it the surface protoplasm appears more transparent and obliquely striated as if clothed with cilia. This form is usually met with in the angle between the body-wall and the skeletal sheath, or at the extreme apex of the cœlenteron in the oral cone. A specimen is shown in the latter position on the left half of Pl. XIII. fig. 5.

Antipathella minor.

The ectoderm of *Antipathella minor* contains the same histological elements as that of *Antipathella subpinnata*, but the individual cells are grouped somewhat differently. The ectoderm of the tentacles consists as usual of batteries of nematocysts and groups of hyaline gland cells arranged alternately. The surface of the layer is raised into irregular rugæ, which are arranged transversely in interrupted series around a tentacle. The rugæ vary from 0·116 to 0·175 mm. or more in length, and have a mean diameter of about 0·03 mm. near the centre, but taper towards each extremity. In longitudinal sections of a tentacle the transverse rugæ are indicated by crenations of the surface. Unlike the usual arrangement in *Antipathella subpinnata*, the batteries of nematocysts are here the most prominent cells of the ectoderm, each raised ridge corresponding to an elongate battery of nematocysts. In sections the batteries are seen to form wedge-shaped groups of cells, limited laterally by two lines which gradually converge towards the base of the layer. The broad end of each wedge-shaped area is occupied by a number of closely-arranged nematocysts, which occupy the outer third of the band. Beneath the adult nematocysts a large number of deeply-stained oval nuclei occur, which are evidently imbedded in slender thread-like cells. The groups of

hyaline gland cells are situated in the depressions between adjoining rugæ, and never project beyond the batteries of nematocysts. On this account the arrangement of the ectoderm cells in this species has a close resemblance to that found in *Leiopathes glaberrima* (Pl. XV. fig. 3).

In all the specimens examined by means of horizontal sections, the stomodæum was found to be relatively small. The portion contained within the oral cone is about 0·22 mm. long and 0·15 mm. broad. It opens into the cœlenteron by a funnel-shaped aperture, the lumen of which is entirely occupied by branched mesenterial filaments.

The entoderm is not very rich in gland cells, and in this respect presents a marked contrast to that of *Antipathella subpinnata*. It appears to consist chiefly of elongate, ribbon-like, epithelial cells, each with a large round nucleus. Each epithelial cell extends from the surface of the layer to near the base, and possibly may be continued basally into a short contractile filament, as in Actiniaria. In portions of the entoderm containing gland cells, the epithelial cells between them become constricted towards the centre, and thus present a dilation at each extremity. Sexual cells were not observed in all the specimens, but in a few, isolated ova were contained within the transverse mesenteries near their point of union with the lateral body-wall.

Antipathella assimilis.

In this species the structure of the ectoderm and entoderm is similar to those of *Antipathella minor*, but the batteries of nematocysts do not taper so rapidly towards the base. The mouth is slit-like, but a short distance beneath it the lumen of the stomodæum becomes widely oval. The inner aperture is funnel-shaped, but the portion of its circumference corresponding to each sagittal tentacle, *i.e.*, between the two pairs of directive mesenteries, is not continued to so low a level as the other portions. Laterally the stomodæum is continued on each side as a slightly-curved plate, which is fused with a transverse mesentery and stretches across from a directive mesentery at one end of the body axis to its fellow at the opposite extremity.

Testis.—All the specimens observed contained a number of spermatic capsules imbedded within the transverse mesenteries. They have usually an oval outline, the largest observed measuring 0·224 mm. × 0·159 mm. Around the periphery of each capsule a number of germinal cells are to be observed, from which the spermatozoa are derived. These cells are distinctly larger than any of the others, and each contains a large nucleus which stains deeply. In the younger capsules the inner portion is filled with cells in various stages of division, and centrally with young spermatozoa. With an increase in size a lumen appears within the capsule, which is usually situated somewhat excentrically. In such cases the flagella of the spermatozoa may be recognised as

delicate lines arranged somewhat radially around the lumen. The subjects of oogenesis and spermatogenesis in the Antipathidæ will be discussed in detail in a subsequent paper.

Antipathella contorta.

At present I only propose to refer to one point in the structure of this species, viz., to the situation of the ova. All the specimens examined contained ova in various stages of development, but in this species they are apparently larger and less numerous than in any other species of the genus which has come under my notice. The largest observed have a diameter of 0·34 mm. From two to five ova, according to their size, cause a considerable dilation of the lateral sections of the cœlenteron, which is very marked in horizontal sections. In several cases I was able to satisfy myself that the ova are contained within mesoglœal capsules (as in Schizopathinæ), and not within a thickened mass of entoderm, as appears to be the case in *Antipathella subpinnata*. In sections of a mesentery, at a point where it contains only one ovum, the mesoglœa on leaving the body-wall consists of a single thin layer up to the point where the ovum is situated. Here it becomes split up into two portions, which completely surround the ovum, and then ultimately become united again beyond the ovum into a single layer. At the free margin of the mesentery the mesoglœa again becomes divided into two portions, which form a short transverse bar at right angles to the breadth of the mesentery. The whole is clothed with a layer of entoderm, which, however, is thinner around the ovum than in other portions of the mesentery. Here evidently the ova are developed under the same conditions as in Actiniaria. They arise from entodermal cells, but undergo their elaboration within the mesoglœa.

Antipathes dichotoma.

The polyps of *Antipathes dichotoma*, and apparently also of other species of the genus (*e.g.*, *Antipathes arborea* and *Antipathes virgata*), are larger than those of any other ramose Antipathinæ known at present. The general form of the polyp and the arrangement of the mesenteries has already been described (p. 41). The ova are contained in a specialised band of cells stretching across from near the lateral margin of a polyp to the lower portion of the stomodæum. Its situation is best understood from a study of transverse vertical sections (Pl. XIV. fig. 1). The band contains a median strand of mesoglœa continuous with that of the body-wall and stomodæum, and on each side is a layer of entoderm of the usual structure. The ova are apparently enclosed within semi-fibrous capsules united to the layer of mesoglœa which passes the whole length of the band. Simple or branched ribbon-like mesenterial filaments occupy

the portion of the cœlenteron beneath the ovary, and in some sections are seen to be united to the lower lateral angle of the ovarian mesoglœa.

Ectoderm.—The ectoderm varies from 0·04 to 0·06 mm. in thickness, and differs considerably in structure from that of *Antipathella*. The surface of the ectoderm is raised into innumerable small rounded papillæ, varying from 0·09 to 0·117 mm. in diameter. Longitudinal sections of a tentacle taken near the surface (Pl. XIII. fig. 9), show that the centre of each papilla consists of a battery of nematocysts, whilst the margin and the depression between adjoining papillæ is occupied by gland cells. These papillæ are most marked on the tentacles and upper portion of the polyp. The surface of the ectoderm becomes smooth towards the base of a polyp. The nematocysts vary from 15 μ to 24 μ in length and have a diameter of about 1·5 μ; they are similar to those of *Antipathella* in all respects excepting size. The gland cells, on the other hand, are quite different. In longitudinal sections of a tentacle (Pl. XIV. fig. 5), they are seen to occupy the depressions between adjoining papillæ, but never extend to the base of the layer, as in *Antipathella*. The depressions in which the gland cells are situated are usually much more marked than is shown in the figure. The gland cells vary from 23 μ to 25 μ in length in the tentacles, and are filled with dense refractive granules. All the ectodermal glands of this species are apparently of the granular type.

The fibrous ("sensory") layer of the ectoderm is of considerable thickness (23 μ to 26 μ). The fibres are very numerous and delicate, and extend from the bases of the nematocysts and gland cells to the mesoglœa. At the base of the layer a number of ganglia occur (Pl. XIV. fig. 5, *ga*), which appear more numerous than in *Antipathella*. Some of the fibres beneath the batteries of nematocysts present two or three bead-like thickenings as is figured by Jourdan for the Actiniaria.

The ectodermal muscular layer is well developed in *Antipathes dichotoma*, and consists of a single row of longitudinal fibres applied to the smooth surface of the mesoglœa. In transverse sections of a tentacle the elongate slender fibres constituting the greater portion of the middle layer of the ectoderm appear to be continuous with the specialised longitudinal fibres of the muscular layer. A similar appearance is presented in the ectoderm of the base (Pl. XIV. fig. 6, *f*). The ectodermal musculature does not apparently attain so much importance in the stomodæum as in other parts.

In the cœnenchyma, consisting of the fused bases of the polyps at the back of a branch, there is an almost total absence of nematocysts. In sagittal sections they are seen to become less numerous on the body-wall, and towards the base they usually disappear altogether. The gland cells, on the other hand, increase considerably in number, and ultimately constitute the greater portion of the surface ectoderm. They are here, however, more irregular in size and shape, and some do not reach the surface. The slender fibres appear to be more numerous, and some of them may be clearly seen to reach the surface of the ectoderm. Near the base of the fibrous layer numerous irregular groups of granules

occur which stain in the same manner as the granular gland cells, but no cell wall has been observed (*cf.* Pl. XIV. fig. 6).

Mesoglœa.—The mesoglœa of *Antipathes* is similar to that of other Antipathinæ, but in many cases transverse striæ have been observed to occur in it at irregular intervals (Pl. XIV. fig. 6, *me*). It appears possible that these may be artificial products, but they have not been observed in other genera. The mesoglœa is of considerable thickness in this genus (31 to 42 μ).

Entoderm.—The entoderm is relatively thin and consists chiefly of irregular hyaline gland cells situated near the base of the layer, above which a number of small cubical cells usually occur (Pl. XIV. fig. 6, *e*). These may correspond with the epithelial cells of *Antipathella*, but their outline is not well defined in the specimens examined. The entodermal muscular layer is rudimentary and, as in *Antipathella subpinnata*, is most readily observed in vertical sections of the stomodæum.

The inner aperture of the stomodæum is somewhat funnel-shaped, and the lower border is continued for some distance along the free lower margin of the transverse mesenteries and is also continued on to the directive mesenteries. Its course is best studied by means of a consecutive series of sagittal sections. Starting from the stomodæal lumen the sections first pass through the wall of the stomodæum and a little later sections of a transverse mesentery are reached. The mesentery consists of a thin vertical plate of mesoglœa clothed on each side by a rather thin layer of entoderm of normal structure. Its base is fused with a moderately thick transverse plate of tissue, which is a reflexed portion of the stomodæum. The mesoglœa of the mesentery and stomodæum is thickened at the point of fusion. The upper surface of this transverse plate is clothed with a layer of entoderm, thicker than that of the mesentery. The lower surface consists of stomodæal ectoderm cells, which present the characteristic staining with borax-carmine. A little nearer to the lateral extremity the two directive mesenteries, which proceed from the angles of the stomodæum, are well marked. They consist, like the transverse mesentery, of a delicate strand of mesoglœa clothed on each side with entoderm, and reach to a point slightly below the recurved stomodæal plate, with which they are fused. A thickening is formed at the lower border of each directive mesentery, consisting of entoderm cells above and of stomodæal ectoderm cells beneath; the lower ectodermal border is markedly curved. The recurved stomodæal plate next loses its connection with the directive mesenteries, and in the succeeding sections becomes gradually reduced in diameter until it forms a thickening of the lower border of the transverse mesentery, which is no thicker than the terminal dilation of a mesenterial filament. Ultimately both directive and transverse mesenteries have a free thickened border consisting of cells derived from the ectoderm of the stomodæum and apparently similar to the median lobe of the Actinian mesenterial filament.

Ova.—The ova are relatively large and frequently measure 0·25 mm. in diameter.

They are contained within semi-fibrous capsules, which appear to be attached to the mesoglœa, but I am uncertain whether they are derived from it. The mesoglœa does not stain in borax-carmine in any of the Antipathinæ yet examined, whilst the capsule surrounding each ovum assumes a distinct carmine tint. It may therefore possibly prove to be a true vitelline membrane. The mesoglœa of Hexactiniæ has been shown by R. Hertwig to stain red in picro-carmine, but material preserved for a long time in spirit does not apparently take the stain so well.

Leiopathes glaberrima.

The zooids of *Leiopathes glaberrima* are very unequal in size, owing to the formation of new zooids at irregular intervals by a process of budding. An elongation of the zooid in the transverse axis is never well marked. Apparently the sagittal tentacles, which are larger than the others, sink to a lower level in older individuals. In such cases horizontal sections taken at a point above the insertion of the sagittal tentacles are oblong, the greatest diameter corresponding with the transverse axis (*cf.* figs. 1, 2 and 3, p. 37). The fully-developed zooids are arranged about four to a centimetre, but in cases where young individuals are interposed between the adults there may be five or six to a centimetre. In large degenerate zooids the ectoderm may be 0·4 mm. thick, and the cells composing it quite indistinct, whilst the entoderm remains quite normal. Subsequently the whole of the zooidal tissues become degenerate, and form oval bead-like swellings of the cœnenchyma, which are about 1 mm. in diameter. These are first recognisable at a point from 2 to 3·5 cm. from the apex of a branchlet, and form oval thickenings, four or five of which are arranged to a centimetre. Possibly the early atrophy of functional zooids may account for the fact that the spines of this species are confined to the more slender portions of the sclerenchyma.

Ectoderm.—The ectoderm of the tentacles is raised into small oval papillæ, the long axes of which are arranged transversely. In longitudinal sections of a tentacle these papillæ appear as irregular crenations (Pl. XV. fig. 3). Each crenation is occupied by a fan-shaped bundle of nematocysts, beneath which elongate thread-like cells extend to the base of the layer. Each battery in section is from 0·02 to 0·04 cm. broad at the surface, but becomes rapidly contracted towards the middle, and is dilated again near the base of the layer. The nematocysts are 0·02 to 0·03 mm. long, and are broader at their distal, than at their proximal, ends. A number of the thread-like cells beneath them have large oval nuclei which stain deeply; others which are more slender are perhaps sensory in function. The space between adjoining batteries of nematocysts is occupied by a group of hyaline gland cells. The glandular patches are usually more or less oval in outline, and have a diameter of 0·02 to 0·04 mm. near the middle. The clusters rapidly taper towards the surface of the ectoderm, and open on the narrow transverse

furrows, separating the batteries of nematocysts. The gland cells of each group are separated from one another by slender thread-like cells, similar to those between and beneath the nematocysts. A nervous layer is more or less well marked at the base of the ectoderm, but is granular in the specimens examined. An ectodermal row of muscular fibres occurs, which is in some parts more fully developed than in *Antipathes* and *Antipathella*. The ectoderm is about 0·05 mm. thick near the middle of a tentacle, but towards the base the layer becomes much thickened, and the nematocysts are observable as small isolated clusters of cells, which extend for no great depth into the general mass of cells. In sagittal sections of a zooid (Pl. XV. fig. 4) the batteries of nematocysts are often indistinguishable on the surface of the body-wall and peristome, where the ectoderm is much thickened and considerably modified. In such situations the greater portion of the ectoderm consists of an irregular faintly-stained reticulum, enclosing hyaline cells. Nearly all the histological elements shown in the tentacles (Pl. XV. fig. 3, *ect*) have either disappeared or become so much modified as to be no longer recognisable. In horizontal sections the ectoderm, under such circumstances, is seen to be invaded by a number of slender mesoglœal processes, which are often branched, and undoubtedly form a part of the reticulum referred to. I have been unable to decide how far these processes extend, but the whole structure is so remarkable as to require a renewed study. The appearance presented recalls the condition of the ectodermal surface of the mesoglœa in certain Challenger Actiniaria described by R. Hertwig (*e.g.*, *Ilyanthopsis*, *Hormathia*, and *Phellia spinifera*).[1] In *Ilyanthopsis longifilis* the muscular pleats of the oral disc are slightly arborescent and arranged close together. At the free edge of each pleat mesoglœal fibres radiate into the ectoderm and are for some distance connected into bundles. In *Phellia spinifera* the mesoglœal ingrowths are stronger, and bear muscular fibres on each side throughout their entire length, whilst in some parts they become fused together into an irregular reticulum. It appears probable that the more complex muscular folds of many Hexactiniæ are due to similar ingrowths of the mesoglœa. It is worthy of note that in *Leiopathes* the longitudinal muscular fibres of the ectoderm are not confined to the normal surface of the mesoglœa, but may be seen to follow the outline of the mesoglœal processes for a short distance as in *Ilyanthopsis*. This layer is therefore not always flat as in the genera previously described. On this account there is a closer resemblance to the ectodermal muscular layer of *Cirripathes propinqua*, but the fibres in *Leiopathes* are not so thick.

Stomodæum.—The stomodæum of *Leiopathes glaberrima* is rather short, and does not extend into the lower two-thirds of the cœlenteron, excepting in that portion of it which borders the transverse axis. In this region the stomodæum is continued along the free margin of the transverse mesenteries, and the cells forming the rounded free extremity of each mesenterial filament are apparently derived from it (Pl. XV. fig. 4).

[1] Zool. Chall. Exp., pt. lxxiii. pl. ii. figs. 2, 3, and 8.

The ectoderm of the stomodæum is considerably folded, and contains a number of hyaline gland cells near the surface, between which are bundles of spindle-shaped cells with deeply-stained nuclei. Between the basal ends of the spindle-shaped cells another row of hyaline gland cells occurs, the base of each cell being imbedded in a thin nervous layer. A few small, oval, granular gland cells may also be distinguished at irregular intervals near the surface of the layer, which are similar to those of *Antipathes dichotoma*.

Mesoglœa.—The mesoglœa varies from 2 to 5 μ in thickness, and apparently only differs from that of *Antipathes* and *Antipathella* in having frequently a dentate instead of a smooth surface.

Entoderm.—The entoderm is relatively thick, and consists chiefly of oval hyaline gland cells, between which a number of elongate thread-like cells occur. The surface of the layer is usually occupied by a row of epithelial cells which taper below to a fine thread, but in portions where the entoderm is thinner this row is not distinct. The gland cells do not stain in carmine or hæmatoxylin, but frequently appear to contain a reticulate or granular coagulum (Pl. XV. fig. 3, *g*). The entodermal surface of the mesoglœa bears a row of circular muscular fibres, which extend from the body-wall, through the peristome, to the tentacles. The surface of the mesoglœa is dentate in many parts, and the layer of muscular fibres follows the dentate outline. In horizontal sections the middle portion of each transverse mesentery is seen to be considerably thickened (0·10 to 0·18 mm.), and contains two or more rows of gland cells. Those near the surface are hyaline, but others near the base of the layer are filled with a finely granular mass which does not stain.

The mesenterial filaments are plate-like folds of the free margin of the transverse mesenteries (Pl. XV. figs. 4, 5). In transverse vertical sections of a zooid each filament is seen to consist of two portions. The rounded and slightly dilated free extremity stains deeply, and has a structure which corresponds precisely with that of the stomodæal ectoderm, whilst the remaining portion of the filament does not stain so deeply, and consists of a median strand of mesoglœa clothed on each side by entoderm. The large oval gland cells of the entoderm are very prominent (Pl. XV. fig. 5, *g*) and often measure 23×16 μ.

Parantipathes larix.

The zooid is relatively more elongate in this species than in any other with which I am acquainted. The tentacles are elongate and slender, and the whole of the zooidal tissues are unusually thin. The body-wall only measures from 64 to 75 μ in thickness. A series of horizontal sections show the variation in the shape of the stomodæum, the main features of which appear constant. In the upper sections the lumen is slit-like or more rarely oval, and the greatest diameter corresponds with the sagittal axis. Usually

the middle of each side of the stomodæum is also slightly folded. A little lower down these lateral folds become more important, and the lumen is for some time cross-shaped. The stomodæum reaches nearly to the base of the zooid, and in its lower portion the lateral folds become so important as to bring about a considerable elongation in the transverse axis. In this part, therefore, the lumen of the stomodæum corresponds in shape with that of Amphianthidæ. The ectoderm of the stomodæum is continued on to the free border of the transverse mesenteries as in other forms. In transverse vertical sections, passing in a plane a little to one side of the transverse mesenteries, the stomodæum is seen to be continued laterally nearly to the extremity of the zooid, and ends at a point under the lateral tentacles (see Pl. XV. fig. 1, right half of figure). The change in the position of the long axis of the stomodæum is also well shown in transverse vertical sections. In Pl. XV. fig. 1, the upper portion of the lumen is slit-like, and the greatest diameter is in a plane at right angles to the one figured. Below, the transverse elongation is considerably greater than that in the sagittal axis.

Ectoderm.—The surface ectoderm of the tentacles is slightly raised into small rounded papillæ, the centre of which is occupied by a bundle of nematocysts, whilst a few deeply-stained granular gland cells are distributed at various points around the periphery. The papillæ are about 0·06 mm. in diameter. They are very numerous near the apex of a tentacle, but gradually become more isolated below.

In longitudinal sections of a tentacle the individual nematocysts of a battery are all subparallel and at right angles to the surface. The ectoderm is here 38 μ thick, and the batteries of nematocysts are about 35 μ in diameter. The nematocysts are of considerable length (27 μ) in proportion to the thickness of the ectoderm, and the area beneath them is probably occupied by slender fibres, the large nuclei of which were, however, only observed. The granular gland cells arranged around each battery are neither so numerous nor so regularly arranged as those of *Antipathes dichotoma*. In sections parallel with the surface of a tentacle the granular gland cells are seen to be arranged singly or in pairs at various points around the periphery of each battery, but there is usually a considerable interval between them. Near the apex of a tentacle the surface ectoderm consists almost entirely of batteries of nematocysts, but towards the middle they become more isolated, and on the body-wall are separated by intermediate masses of tissue, which may be 67 μ or more in width. These intermediate areas contain oval hyaline cells, each provided with a round nucleus. They sometimes appear to be imbedded in a protoplasmic reticulum containing nuclei, but in other parts distinct spindle-shaped cells may be observed between them, extending from the nervous layer to the surface. Each cell has a median protoplasmic dilation in which a deeply-stained round nucleus is situated. The nervous layer is not important, but a few small ganglion cells have been observed at its base. An ectodermal muscular layer is very imperfectly developed, but a few delicate fibres occur applied to the mesoglœa.

Stomodæum.—The ectoderm of the stomodæum has an interesting structure, which appears to approach the Actinian type more closely than that of any other species yet examined, and is unusually rich in "Stützzellen." The surface of the layer appears to be chiefly composed of epithelial cells, which taper below to a slender filament. The whole of the middle portion of the layer is filled with a very large number of small oval or elongate cells, which are apparently of the granular gland type. Each cell stains deeply in hæmatoxylin, and under a high power reveals a double row of small round granules in its interior. Slender fibres appear to extend from the base of this glandular layer to the nervous layer of the ectoderm, and between them a number of hyaline gland (?) cells occur. The small granular gland cells appear to vary considerably in length, but usually have a similar diameter; here and there, however, a very large one occurs, similar to those of *Antipathes dichotoma*.

Mesoglœa.—The mesoglœa is usually very thin and structureless, rarely exceeding 15 μ in thickness. It presents no features of special interest.

Entoderm.—The entoderm usually varies from 14 to 20 μ in thickness, but at the base of a tentacle may be considerably thickened. The layer appears to consist chiefly, in its thinner portions, of small cubical cells, which contain large oval nuclei. In the thicker parts of the layer a number of oval or angular hyaline gland cells occur near the base, each of which has a small round nucleus. Entodermal muscular fibres have not been observed. The mesenterial filaments are elongate ribbon-like organs, each of which is provided with a rounded dilation at its free extremity. Some of them are apparently forked near the apex. As in other Antipathinæ the shaft of the filament is clothed on each side by entoderm, but the terminal dilation has the same structure as the ectoderm of the stomodæum. In this portion the small oval granular gland cells are well marked.

No ova or spermatozoa have been observed in the majority of the zooids examined, but in two instances what appear to be immature spermatic capsules have been found. In such cases a narrow semicircular band of tissue is found in the lateral sections of the cœlenteron, which at its two extremities is fused with a confused mass of mesenterial filaments. The arched portion is situated just beneath the curved peristome and follows its outline. This band of tissue contains a number of oval capsules, about 45 μ long and 32 μ broad. The capsules are filled with a large number of small round cells, each of which shows a variable number of nuclei. All the cells appear to be at a similar stage of subdivision, and no cells in the resting stage were observed near the wall of the capsule, as in other forms.

Cirripathes propinqua.

The type specimen of *Cirripathes propinqua* is not sufficiently well preserved to show the general histological structure, but the muscular system is unusually well developed, and the arrangement of the fibres has a closer resemblance to that of Actiniaria than has yet been observed in any other Antipatharia. In the tentacles the ectoderm is about 0·06 mm. in thickness, and the mesoglœa 0·03 mm. The entoderm is considerably folded, and fills up the lumen of the tentacle. It varies in thickness from 29 to 87 μ. Nematocysts occupy almost the whole surface of the tentacles, which are apparently not folded or papillose. On the body-wall the nematocysts are not numerous, and their place appears to be taken by elongate tapering epithelial cells (Stützzellen). The mesoglœa is apparently dentate on both its ectodermal and entodermal surfaces, and bears on each side a well-developed row of muscular fibres, which follow the irregular outline of the mesoglœa. The ectodermal layer of muscular fibres appears to be more than usually developed in the curve by which the peristome passes into the body-wall. The entodermal muscular layer has a greater development than that of any other species studied. This is the only species in which undoubted muscular fibres have been observed in the mesenteries. A sagittal section of a zooid, cutting the transverse mesenteries at right angles, shows a delicate row of muscular fibres applied to each side of the mesoglœa. The mesoglœa is, however, not dentate as in other parts. Better preserved material is necessary before one can decide whether there is any relation between the direction of the muscular bands of the mesenteries in *Cirripathes* and those of other Zoantharia.

The interzooidal areas bear a large number of slender mesoglœal ridges, clothed on each side by entoderm, which have a direction chiefly transverse to that of the skeletal axis. The appearance of these ridges in transverse section is shown in Pl. XIV. fig. 7 *sep*. They vary considerably in length, the longest being situated at the lateral margins of each zooid. In the interzooidal regions (Pl. XIV. fig. 7, *c*) the majority are very short, but longer ones occur at irregular intervals. A delicate row of muscular fibres is applied to the surface of the mesoglœa on each side. The floor of each zooid consists of a delicate membrane, formed by a layer of mesoglœa, lined internally by entoderm and externally by the axis epithelium. The cells of the latter are very irregular and sometimes columnar. The membrane is folded inwards towards the zooid at intervals, each fold corresponding to the position of a spine.

All the specimens examined have the cœlenteron almost completely filled with ova, but the intermediate tissue is granular. In horizontal sections the ova are seen to be contained in very large semicircular dilations of the transverse mesenteries. They also fill up the lower portion of the lumen of the tentacles and extend more or less into the interzooidal areas; they sometimes, too, form relatively large rounded masses between the interzooidal septa.

Aphanipathes sarothamnoides.

In the genus *Aphanipathes*, the horny skeleton frequently bears exceedingly long spines, which project into the zooidal tissues in all directions. Pl. XIV. fig. 2 shows a subhorizontal section of a zooid of *Aphanipathes sarothamnoides* in which the spines are shown in transverse section. Two spines are seen to penetrate the transverse mesentery on each side, whilst another is imbedded in the stomodæal ectoderm. In other sections of the same series, taken nearer to the oral surface, the latter spine is seen to project freely into the lumen of the stomodæum. Each spine is surrounded by a sheath of tissue, which is a dilation of the axial skeletal sheath. In transverse section (Pl. XIV. fig. 3) the sheath consists internally of a flattened row of cells with oval nuclei, which constitutes the axis epithelium. In the middle is a layer of mesoglœa of variable thickness, whilst externally there is a layer of entoderm, consisting chiefly of small cubical cells with round nuclei. The entodermal layer consists usually of only a single row of cells, but in some parts the layer is thickened, and may then be two or three rows deep.

In sagittal sections the sclerenchyma is seen to be remarkably thick in proportion to the diameter of a zooid, and the cœlenteron is reduced to a narrow crescent-shaped cavity between the body-wall and the skeletal sheath. The skeletal sheath has a structure similar to that already described, and differs from that of other genera chiefly on account of the thinness of its entoderm. The axis epithelium is irregularly developed. Usually it consists of a thin flattened row of cells, but at various points, particularly in the angles at the base of a spine, the layer is considerably thickened and the cells composing it are columnar. At a point corresponding to the position of a spine (in sagittal sections) the skeletal sheath becomes evoluted so as to come in contact with the body-wall. The mesoglœa of the skeletal sheath and that of the body-wall are in contact at this point, but so far as I could ascertain they do not become confluent. In such cases, therefore, the cœlenteron is perforated by a number of vertical columns of tissue, each of which encloses a spine.

Ectoderm.—The ectoderm is about 35 μ thick and does not become so much reduced at the base of a zooid as in some other forms. That of the tentacles is papillose; each papilla contains a central battery of nematocysts and a peripheral ring of granular gland cells which are closely packed. In sagittal sections the gland cells are seen to be large, and filled with deeply-stained granules. The gland cells do not extend to the base of the layer, as in *Antipathella* and *Leiopathes*, but have an arrangement similar to those of *Antipathes*. The lower portion of the layer is occupied by nucleated fibres in the usual manner, which terminate in a thin nervous layer. A row of ectodermal muscular fibres is also present, applied to the outer surface of the mesoglœa of the tentacles and body-wall, but is not well developed.

The stomodæum is similar in structure to that of *Parantipathes larix*. An ectodermal muscular layer has not been observed in the stomodæum.

Mesoglœa.—In *Aphanipathes sarothamnoides* the mesoglœa is unusually thick, and in *Aphanipathes cancellata*, the zooids of which are smaller, it appears to have a similar relative development. In the former species it has an average thickness of 28 μ. This layer appears to be especially thickened in the peristome and body-wall and also in the interzooidal areas (*cf.* Pl. XIV. fig. 2). The mesoglœa is, however, homogeneous throughout, and no fibres or connective-tissue cells have been observed within it, such as occur in that of *Cladopathes plumosa* and many Actiniaria.

Entoderm.—The entoderm varies from 11 to 28 μ in thickness, and presents no features of especial interest. It appears to consist largely of small cubical cells, and is not so richly supplied with hyaline gland cells as that of many other genera. An entodermal muscular layer has not been observed.

Pteropathes fragilis.

The stomodæum of this species is very much folded, and may be best studied by means of a series of horizontal sections. In the upper portion of the oral cone there are usually eight radiating folds, and the lumen is longer in the transverse than in the sagittal axis. At a lower level the lateral folds are much more pronounced, and one or two near each extremity of the sagittal axis become much elongated and are curved inwards, so as to take up a transverse position. Each fold contains a lumen which communicates with the general stomodæal cavity, but this is usually very narrow, and the ectodermal walls are often in contact. In the middle section of the stomodæum the lumen becomes narrowed, and is much elongated in the sagittal axis, so that the directive mesenteries have only a short course in this region. An oblique section of the stomodæum is shown in Pl. XIV. fig. 4, which also shows one pair of directive mesenteries. I am not aware of the existence of such a complicated system of folds in the stomodæum of any other Antipatharian.

Ectoderm.—The ectoderm of the tentacles is papillose, and the papillæ are frequently constricted at the base and appear club-shaped in transverse sections. Each papilla contains a central battery of elongate nematocysts, and a number of large granular gland cells are distributed irregularly around the periphery. The gland cells of the surface ectoderm stain more deeply in hæmatoxylin than those of any other part. Ectodermal muscular fibres are present, but not very well developed.

In the stomodæum the surface layer consists chiefly of ribbon-like "Stützzellen" and slender fibres, both of which apparently extend from the surface to the nervous layer adjoining the mesoglœa. The former appear to have the nuclei contained within the surface dilation of protoplasm, whilst the nuclei of the fibrous cells usually occupy the

middle of the layer. The stomodæal gland cells are seldom found near the surface of the layer, and do not appear to be so numerous as in many other species. A number of large subcylindrical gland cells occur near the middle of the layer, which take a deep homogeneous stain in hæmatoxylin. Others, which are small and oval, are more distinctly granular. A well-marked and relatively thick nervous layer is found beneath the epithelial layer, and a number of ganglion cells may frequently be distinguished at its base. Finally, a row of ectodermal muscular fibres is applied to the surface of the mesoglœa.

Entoderm.—In transverse sections of a tentacle the entoderm consists of a confused mass of cells, two or three rows deep, the outlines of which are not well defined. Each cell apparently contains a round or oval body with deeply-stained granules around its periphery. The zooids examined are not sufficiently well preserved to allow one to decide whether these are simply nuclei or a small type of granular gland cell interposed between more homogeneous epithelial cells. The entoderm of the body-wall contains a number of ribbon-shaped epithelial cells, each bearing a nucleus at the base of the protoplasmic dilation which reaches the surface of the layer. A number of hyaline gland cells occupy the lower portion of the layer and are interposed between the slender proximal ends of the epithelial cells. No entodermal muscular layer has been observed in this species.

Testis.—The whole of the zooids examined contain a large number of spermatic capsules in various stages of development. These are present in such quantity as to entirely obliterate the lumen of the cœlenteron. They appear to be developed in connection with the transverse mesenteries, but are pressed close against the entoderm of the body-wall, and also between the folds of the stomodæum. In most specimens they occupy a considerable portion of the lumen of the tentacles and are pressed into every available space. The spermatic capsules themselves are well preserved, but the tissue in which they are imbedded is more or less granular in the sections examined, so that I have been unable to make out their relations to the mesoglœa of the transverse mesenteries.

Tylopathes crispa.

The general structure of this species is similar to that of *Antipathella subpinnata*. The surface of the tentacles is raised into oval transverse papillæ, the centre of which, as usual, is occupied by a battery of nematocysts, with elongated nucleated fibres beneath. The bundles of nematocysts are sometimes subcylindrical, but at others they are fan-shaped and each bundle of nematocysts and fibres is contracted towards the middle, as in *Leiopathes glaberrima*. A number of hyaline gland cells are interposed between adjoining batteries of nematocysts and pass from the surface to the base of the layer. These hyaline cells contain a large number of yellowish green bodies of irregular outline; these

may perhaps be symbiotic Algæ, which have contracted under the influence of hardening reagents. They are uniformly distributed throughout the hyaline cells of the surface ectoderm, but have not been observed in the stomodæum nor in any portion of the entoderm. This is the only instance known to me of the probable occurrence of symbiotic Algæ in the tissues of Antipathinæ.

All the specimens examined contained a moderate number of pear-shaped spermatic capsules imbedded in the tissues of the transverse mesenteries. The stomodæum appears to be continued laterally along the free border of the transverse mesenteries, which then becomes evoluted at certain points into mesenterial filaments. The rounded free margin of each mesenterial filament has, like that of other genera, the same structure as the stomodæal ectoderm.

Mesenterial Filaments.

Considerable diversity of opinion has been expressed on the origin of the mesenterial filaments of the Anthozoa, and it will be well to review the position taken up by various investigators in view of the possible origin of these structures in Antipatharia, although embryological data are necessary before a positive conclusion can be arrived at.

The mesenterial filaments of Hexactiniæ contain a dilation at the free margin, which consists of three lobes. The median lobe (Nesseldrüsenstreif) consists chiefly of glandular cells and nematocysts, whilst the two lateral lobes (Flimmerstreifen) contain a large number of elongate and ciliated epithelial cells, which are supposed to be concerned in circulation.

In 1879 von Heider, from a study of the structure of *Cerianthus membranaceus*, came to the conclusion that the mesenterial filaments are derived from the ectoderm of the stomodæum, which becomes invaginated along the free margin of a mesentery. This view was based on the fact that the epithelial cells of the mesenterial filaments have the same character as those of the stomodæum, into which they pass without any delimitation. A year later the brothers Hertwig combated this view, and adhered to their former opinion that the mesenterial filaments are entirely of entodermal origin. They point out that the structure of the mesenterial filaments is the same in the incomplete as in the complete mesenteries, and that in the former case the filaments never come in contact with the stomodæum, and thus could not derive cells from it. They point to the fact that histological evidence is insufficient to decide a developmental point, and their observations tend to show that the ectoderm and entoderm of Actiniaria are, histologically, almost indistinguishable from each other. Wilson has shown that in Alcyonaria there are two distinct types of mesenterial filaments, which differ in structure, in development, and also in function. The filaments attached to the "dorsal" pair of mesenteries consist chiefly of elongate narrow epithelial cells, which bear strong

cilia and are to be regarded as organs of circulation. They are formed from the ectoderm by a downward growth of the stomodæum. They are the last to be developed in the oozooid, but the first in the blastozooid. The remaining six mesenterial filaments are all derived from the entoderm, and have a digestive function. With regard to the phylogeny of the mesenterial filaments, Wilson makes the following proposition:—"I would suggest that it is in a high degree probable that the lateral lobes or 'Flimmerstreifen' of Actiniaria, at least in the principal or complete septa, are the homologues of the ectodermic bands of Alcyonaria, and are likewise ectodermic downgrowths from the stomodæum, and that the central lobes or 'Nesseldrüsenstreifen' are homologous with the entodermic filaments. As the Hertwigs have described, if we follow the filament upwards towards the œsophagus, the central lobe disappears and only the lateral lobes remain. The filament is then closely similar to the dorsal filaments of Alcyonaria, which are also bilobed. If we follow the filament downwards, the lateral lobes disappear and the middle lobe remains. The filament is then essentially similar to the entodermic filaments of Alcyonaria" (Mitth. Zool. Stat. Neap., Bd. v. p. 21).[1]

Wilson also states, on the authority of Andres, that there is a certain amount of embryological evidence in favour of the view that the upper part of the filaments of the six principal mesenteries is derived by a downgrowth from the ectoderm of the stomodæum.

Fowler, in a paper on the structure of *Madrepora*, &c., discusses Wilson's view as to the phylogeny of the Anthozoan mesenterial filaments as applied to the Madreporaria, and adds:—"I may here state that, so far as histological evidence from the adult is valuable, it points, in all the Madreporaria that I have yet examined, distinctly in the opposite direction. The central 'Nesseldrüsenstreifen' have precisely the same microscopic appearance as the stomodæal ectoderm; while the 'Flimmerstreifen,' in the unbroken gradation by which they pass into the entoderm and by their characteristic staining, seem to be much more nearly connected with that layer than with the ectoderm, and to exhibit an intermediate condition between the ordinary cubical or pavement cells of the endoderm and the enormously lengthened cells of *Madrepora durvillei*" (Quart. Jour. Micros. Sci., vol. xxvii. pp. 8, 9). This is practically a return to the views of von Heider, as Fowler himself points out.

In the Antipathinæ the structural evidence on this subject appears to me to be almost, if not quite, conclusive. There is no similarity whatever between the ectoderm and the

[1] In the final section of his paper, Wilson discusses the relation of the Anthozoa to the Enterocœla, and points out that morphologically each polyp consists of an anterior and a posterior chamber, together with a variable number of paired lateral chambers, and compares the adult condition in Anthozoa with developmental phases of *Peripatus*. His conclusions are so closely in harmony with those advocated on pp. 57–59 of this Report, that I feel it only just to state that my conclusions have been arrived at quite independently, and that I had not read Wilson's paper until the whole of my Report, with the exception of these last few pages, was in type.

entoderm of these forms, and there is therefore less risk of confusing their derivatives. The cellular constituents of the two layers are different, and in all the species yet examined they behave differently under the influence of staining reagents. The stomodæum also has a different structure from that of the external ectoderm and stains in a characteristic manner. Such a structure and characteristic staining is only found elsewhere in the rounded free extremity of the mesenterial filaments.

The mesenterial filaments themselves usually form elongate ribbon-like structures which contain a central strand of mesoglœa clothed on each side by entoderm (*cf.* Pl. XV. fig. 5). The main portion of each filament not only has the structure of the entoderm, but also stains in the same manner. The free margin, however, has invariably quite a different structure and stains more deeply, and possesses all the characters of the stomodæal ectoderm. Frequently the mesenterial filaments are branched, as in the genus *Leiopathes* and other forms. In such cases the distal portion of the mesoglœa is forked and each fork bears a number of entoderm cells on each side for some distance, but its extremity is clothed with a rounded mass of cells, which are indistinguishable from those of the stomodæal ectoderm. The free extremity of each filament consists of a single lobe in all the species studied, and I have never seen indications of the formation of lateral lobes of different structure, excepting in the rare and doubtful cases of *Antipathella subpinnata* already referred to. In this connection it is interesting to note that in the genus *Cerianthus*, the forms studied by von Heider, the lateral lobes (Flimmerstreifen) are much reduced and, as compared with those of many Hexactiniæ, are quite insignificant. This fact, taken in connection with the absence of the "Flimmerstreifen" in Antipathinæ, renders it possible that they may be phylogenetically of later origin than the median lobe.

In most Antipathinæ the ectoderm of the stomodæum may be distinctly traced to extend for a considerable distance along the free margin of the transverse mesenteries (*cf.* Pl. XIII. fig. 5, and Pl. XV. fig. 5). In the blastozooids, at any rate, the ectoderm appears to reach such a position before the mesenterial filaments are formed, and consequently any outgrowth of the free border of a mesentery to form a mesenterial filament must push before it a cap of ectoderm cells. Such, at any rate, appears to be the probable origin of the median lobe in Antipatharia, but the point must also be studied ontogenetically, and we already know that, in colonial forms, the development of blastozooids is not necessarily a repetition of the ontogenetic process.

General Conclusions.

The leading structural points brought out in this chapter may be summarised in the following manner :—

The *ectoderm* possesses the essential Actinian structure, but the nematocysts are

almost invariably collected into batteries, as in many Madreporaria. Such an arrangement of the nematocysts is not usual in the Actiniaria, but is found in the marginal spherules of certain forms. The batteries of nematocysts are usually surrounded by a more or less complete ring of gland cells. The gland cells may be either hyaline or granular, but the two types are apparently not found in the same species. A nervous layer connected with a row of slender fibres, which are probably sensory in function, is always present near the base of the ectoderm, and ganglia have been demonstrated in it in many instances. An ectodermal muscular layer is apparently always present, but has a variable development. In some genera it is quite unimportant, whereas in others (*e.g.*, *Leiopathes* and *Cirripathes*) the fibres are of considerable thickness and are applied to the dentate surface of the mesoglœa, so that the layer is then somewhat convoluted. The ciliated epithelial cells (Stützzellen) do not form so important a feature of the ectoderm as is the case in Hexactiniæ. The ectoderm of the stomodæum is, so far as my observations go, entirely devoid of nematocysts. It contains granular gland cells of variable size and usually also a number of the hyaline type, which are situated near the base of the layer. The "Stützzellen" are here more important, and are separated from one another by elongate fibrous cells. Unlike the Hexactiniæ the stomodæal ectoderm of Antipathinæ frequently has a muscular layer at its base. A similar layer is also generally present on the body-wall beneath the insertion of the tentacles, in that part namely, where, according to the researches of the Hertwigs, ectodermal muscular fibres are absent in Hexactiniæ.

The *mesoglœa* has a similar structure in all the Antipathinæ examined. It consists of a hyaline or subfibrous layer of variable thickness, and has never been observed to contain isolated connective-tissue cells as in Hexactiniæ. In Cerianthidæ these rounded or stellate connective-tissue cells are, however, rare. In *Cladopathes*, amongst the Schizopathinæ, the mesoglœa is relatively very thick, and is furnished with isolated stellate cells of the Actinian type.

The *entoderm* usually contains only the hyaline type of gland cells. Apparently the glandular elements are more numerous than in Hexactiniæ, and the Stützzellen are less so. The surface of the entoderm frequently consists of an irregular cubical epithelium similar to that of many Madreporaria. No nematocysts have ever been observed in any part of the entoderm. The nervous layer is apparently always represented, but the entodermal muscular system may be rudimentary or absent. In most types the inner surface of the mesoglœa is flat, and a more or less important layer of entodermal muscular fibres may be applied to it, which appears first recognisable in vertical sections of the stomodæum. In *Leiopathes* and *Cirripathes* the inner (as well as the outer) margin of the mesoglœa is dentate, and bears a more or less convoluted layer of entodermal muscular fibres. These are the only genera in which an approach to the entodermal muscular system of Hexactiniæ has been observed. No muscular fibres have as yet been observed in the

entoderm of the mesenteries, excepting in the case of *Cirripathes propinqua*, where a single flat row of delicate fibres is present on each side of the primary mesenteries. This portion of the entodermal muscular system is, however, too rudimentary to admit of a distinction being made according to the direction of the fibres. The comparative development of the ectodermal as compared with the entodermal muscular fibres appears to indicate that the latter are of later origin. The mesenterial filaments are apparently outgrowths from the lower margin of the transverse mesenteries, and bear a cap of ectodermal cells at their free extremities. The reproductive organs are developed in connection with the transverse mesenteries only. The germinal cells are derived from the entoderm and may undergo differentiation within that layer, or may be enclosed in a mesoglœal capsule.

The Antipathinæ approach the Cerianthidæ more closely than the Hexactiniæ in structure, particularly in the following points:—

1. The arrangement of the mesenteries.
2. The relatively thin mesoglœa, which is entirely devoid of stellate connective-tissue cells.
3. The presence of an ectodermal muscular layer in the stomodæum and body-wall.
4. The rudimentary condition of the musculature of the mesenteries.

SYSTEMATIC INDEX.

Note.—Synonyms are printed in *Italics*. The pages on which systematic, morphological, and histological details occur are indicated in bold type.

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PLATE I.

PLATE I.

Figs. 1–3. *Antipathella minor*, n. sp.

Diam.

Fig. 1. The whole corallum; about three-tenths natural size (from a photograph).

Fig. 2. Anterior surface of a branchlet, bearing five polyps, . . . × 6

Fig. 3. Portion of a branchlet, showing the arrangement of the spines, . . × 26

Figs. 4–7. *Antipathella assimilis*, n. sp.

Fig. 4. Apical portion of a colony; about two-thirds natural size (from a photograph).

Fig. 5. Portion of a branchlet and two pinnules, showing the arrangement of the polyps, ... × 6

Fig. 6. Middle portion of a branchlet, showing the arrangement of the spines, × 26

Fig. 7. Apical portion of a branchlet, showing the thickened spines, . × 26

Figs. 8–11. *Antipathella contorta*, n. sp.

Fig. 8. View of one of the smaller branches and its subdivisions as seen from the posterior surface; about two-thirds natural size (from a photograph).

Fig. 9. Portion of a small branchlet, bearing five polyps, . . . × 6

Fig. 10. Reticulum from the lower portion of a specimen, after treatment with caustic potash; about natural size (from a photograph).

Fig. 11. Portion of a branchlet, showing the arrangement of the spines, . × 26

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PLATE II.

PLATE II.

Figs. 1–4. *Cladopathes plumosa*, n. sp.

Diam.

Fig. 1. One of the plumose branches clothed with polyps and cœnenchyma; about two-thirds natural size (from a photograph).

Fig. 2. Portion of a branchlet, showing three triplets of dimorphic zooids, × 6

Fig. 3. Part of the corallum, after treatment with caustic potash, showing the mode of branching; about three-fifths natural size (from a photograph).

Fig. 4. Portion of a branchlet, showing the arrangement of the spines, . × 26

Figs. 5–7. *Antipathella speciosa*, n. sp.

Fig. 5. Corallum covered with a membranous film, soluble in caustic potash; about one-sixth natural size (from a photograph).

Fig. 6. Apical portion of the corallum, after treatment with caustic potash, showing the mode of branching; natural size.

Fig. 7. Portion of a branchlet, showing the arrangement of the spines, . × 26

Fig. 8. [*Antipathes*] *spinescens*, Gray. Three branches; natural size.

Fig. 9. [*Antipathes*] *spinescens*, var. *minor*, nov. A branch and its subdivisions; natural size.

Fig. 10. *Antipathella barbadensis*, n. sp. One of the lower branches, bearing two simple branchlets near the base; natural size.

Fig. 11. *Parantipathes hirta* (Gray). One of the lower branches and its subdivisions; natural size.

Fig. 12. [*Antipathes*] *spinosa* (Carter). Portion of a branchlet, showing the arrangement of the spines, ... × 26

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F. Huth, Lith. Edin.

PLATE III.

PLATE III.

Figs. 1–4. *Tylopathes crispa*, n. sp.

Diam.

Fig. 1. View of a branch seen from the anterior surface; about two-thirds natural size (from a photograph).

Fig. 2. Portion of the cylindrical reticulum, forming the habitation of an Annelid, ... × 2

Fig. 3. Anterior view of a branchlet, showing the form and arrangement of the polyps, ... × 6

Fig. 4. The arrangement of the spines, ... × 26

Figs. 5–9. *Aphanipathes cancellata*, n. sp.

Fig. 5. The whole corallum, with basal dilation; about two-ninths natural size (from a photograph).

Fig. 6. Portion of the reticulum clothed with polyps, showing the mode of branching near the middle of the specimen, . . . × 2

Fig. 7. Apical branches, after treatment with caustic potash, . . . × 2

Fig. 8. Portion of a branchlet, showing the arrangement of the spines, . × 13

Fig. 8*a*. A single spine, more highly magnified, showing serrations, . . × 52

Fig. 9. Anterior view of a portion of the corallum, showing the irregularity in size of the polyps, ... × 9

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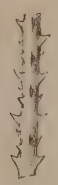
3.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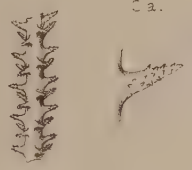
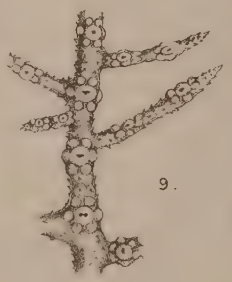
7.


8.
8a.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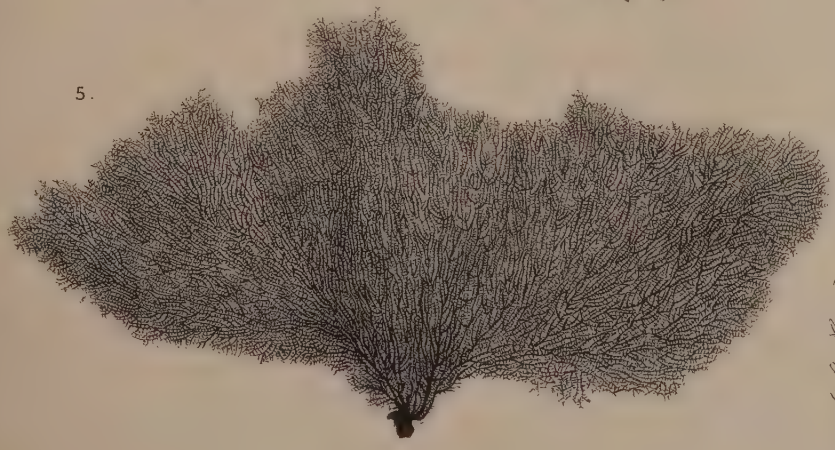
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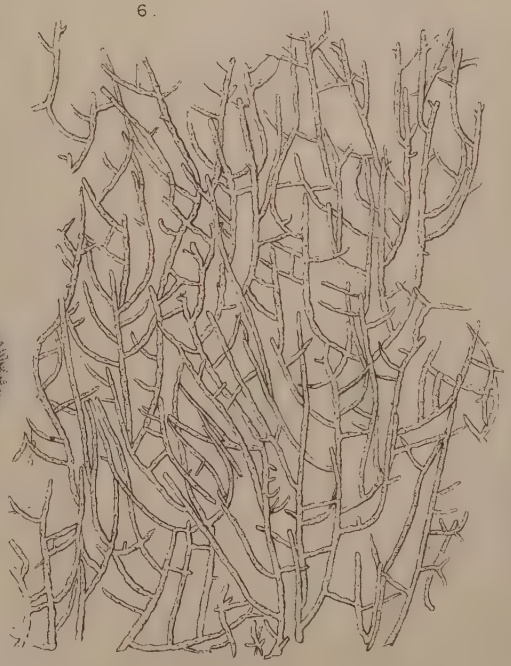

6.

PLATE IV.

PLATE IV.

Figs. 1–4. *Pteropathes fragilis*, n. sp.

Diam.

Fig. 1. Three portions of the corallum, showing the base and mode of branching; one-half natural size.

Fig. 2. Portion of a branchlet, showing the arrangement of the spines, . × 13

Fig. 3. Anterior view of a branch, showing four polyps, . . . × 4

Fig. 4. The same portion seen from the side, ... × 4

Figs. 5–7. [*Antipathes*] *cylindrica*, n. sp.

Fig. 5. The whole corallum, showing the bottle-brush type of growth; about three-fifths natural size (from a photograph).

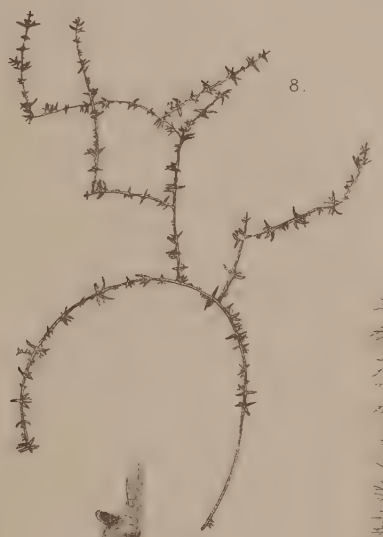
Fig. 6. Four of the branches, forming one revolution of the stem, . . × 2

Fig. 7. Portion of a branchlet, showing the arrangement of the spines, . × 13

Figs. 8, 9. *Leiopathes glaberrima* (Esper).

Fig. 8. Apical portion of the corallum, showing the irregularity in the size and position of the polyps; natural size.

Fig. 9. Portion of a branchlet, showing the position of six polyps, . . × 8



M'Farlane & Erskine, Lith.T. Edin.

PLATE V.

PLATE V.

Figs. 1–5. *Bathypathes patula*, n. sp.

Diam.

Fig. 1. The whole corallum clothed with polyps and cœnenchyma to near the base; natural size.

Fig. 2. View of a portion of the stem and its branches, showing the form and position of the dimorphic zooids, ... × 2

Fig. 3. Terminal portion of a branch, the distal half of which is membranous and devoid of spines, ... × 5

Fig. 4. Middle portion of a branch, showing the typical arrangement of spines, × 13

Fig. 5. *Bathypathes patula*, var. *plenispina*, nov. Middle portion of a branch, showing the arrangement of the spines, ... × 13

Figs. 6–9. *Aphanipathes sarothamnoides*, n. sp.

Fig. 6. Portion of the corallum, showing the mode of branching; about one-half natural size (from a photograph).

Fig. 7. One of the branches and its derivatives; natural size.

Fig. 8. Anterior view of part of a branchlet, showing five polyps, . . × 4

Fig. 9. Portion of a branchlet, showing the arrangement of the spines, . × 13

Fig. 9*a*. One spine; more highly magnified, ... × 52

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PLATE VI.

PLATE VI.

Figs. 1–3. *Schizopathes conferta*, n. sp.

Diam.

Fig. 1. The type specimen; natural size.

Fig. 2. Side view of portion of a branch, showing nine dimorphic zooids, . × 2

Fig. 3. Portion of a branch, showing the arrangement of the spines, . × 13

Figs. 4–6. *Bathypathes lyra*, n. sp.

Fig. 4. The whole corallum, attached to a stone; natural size.

Fig. 5. Portion of a branch, showing three dimorphic zooids—a gastrozooid in the centre and a gonozooid at each side, . . . × 8

Fig. 6. Portion of a branch, showing the arrangement of the spines, . × 13

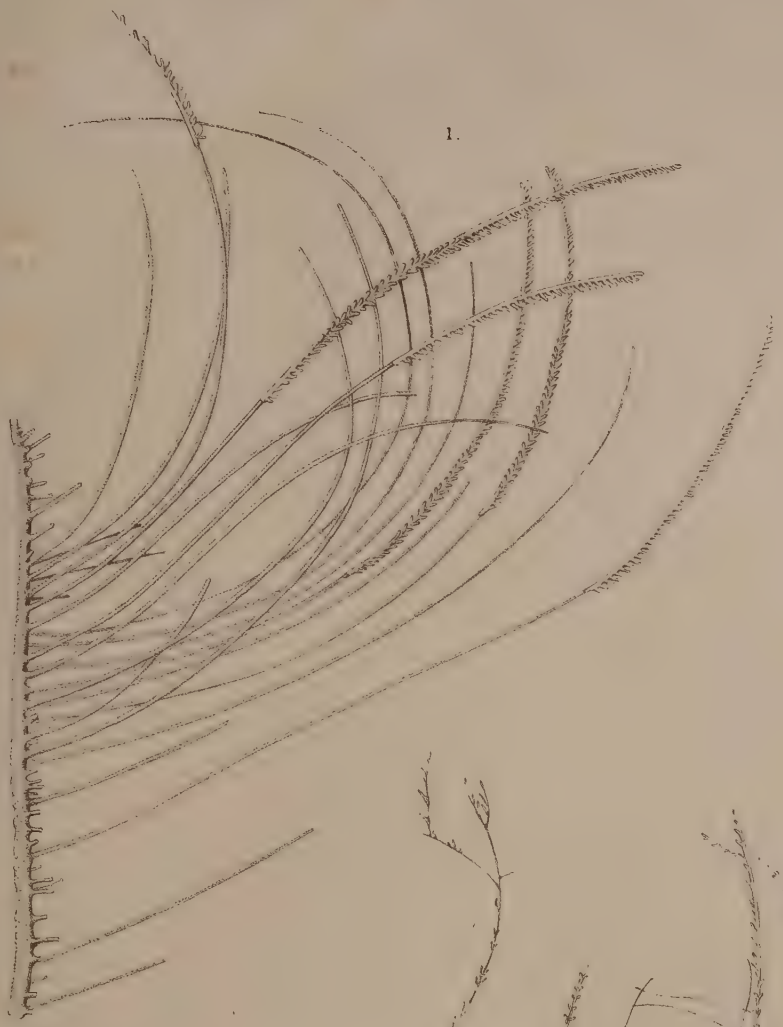
Figs. 7–10. *Bathypathes tenuis*, n. sp.

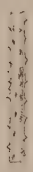
Fig. 7. The whole corallum, attached to a stone; natural size.

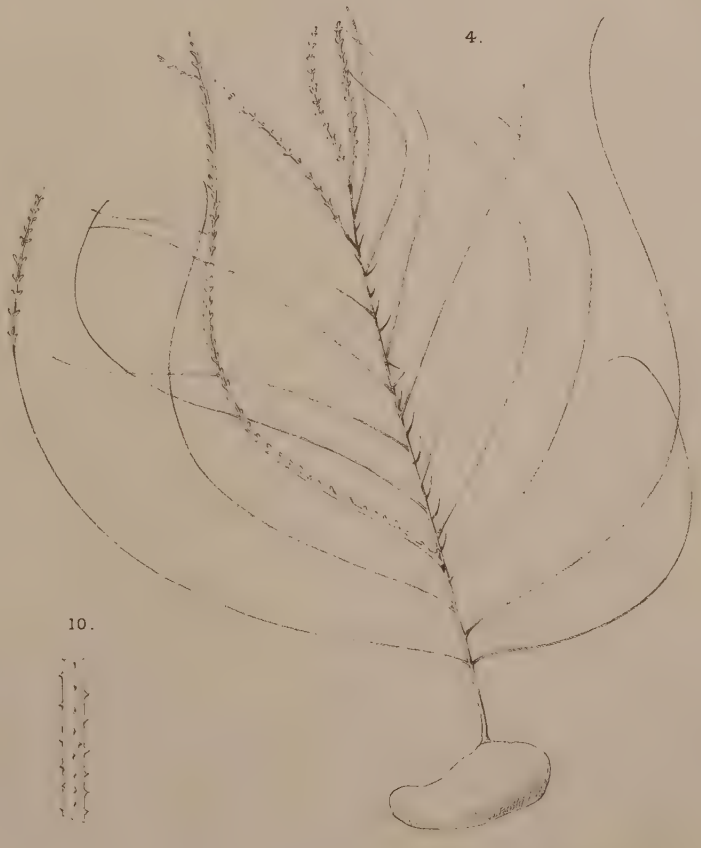
Fig. 8. Apical portion of another specimen; natural size.

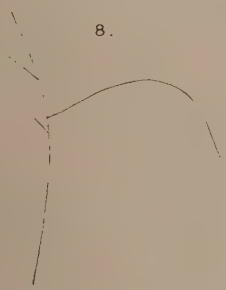
Fig. 9. Portion of a branch, showing the arrangement of the spines, . × 13

Fig. 10. Lower portion of the stem, showing the arrangement of the spines, . × 13









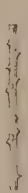


PLATE VII.

PLATE VII.

Taxipathes recta, n. sp.

Diam.

Fig. 1. Upper portion of a corallum, showing the mode of branching; natural size.

Fig. 2. Portion of a pinnule, showing the dimorphic zooids to be isolated. (In other portions they are much closer together), . . × 4

Fig. 3. Portion of a pinnule, showing the arrangement of the spines, . . × 13

Fig. 3*a*. A single spine, ... × 26

Fig. 4. Diagram of the arrangement of the pinnules, as seen from above.

Fig. 5. Diagram of the arrangement of the pinnules, as seen from the side.

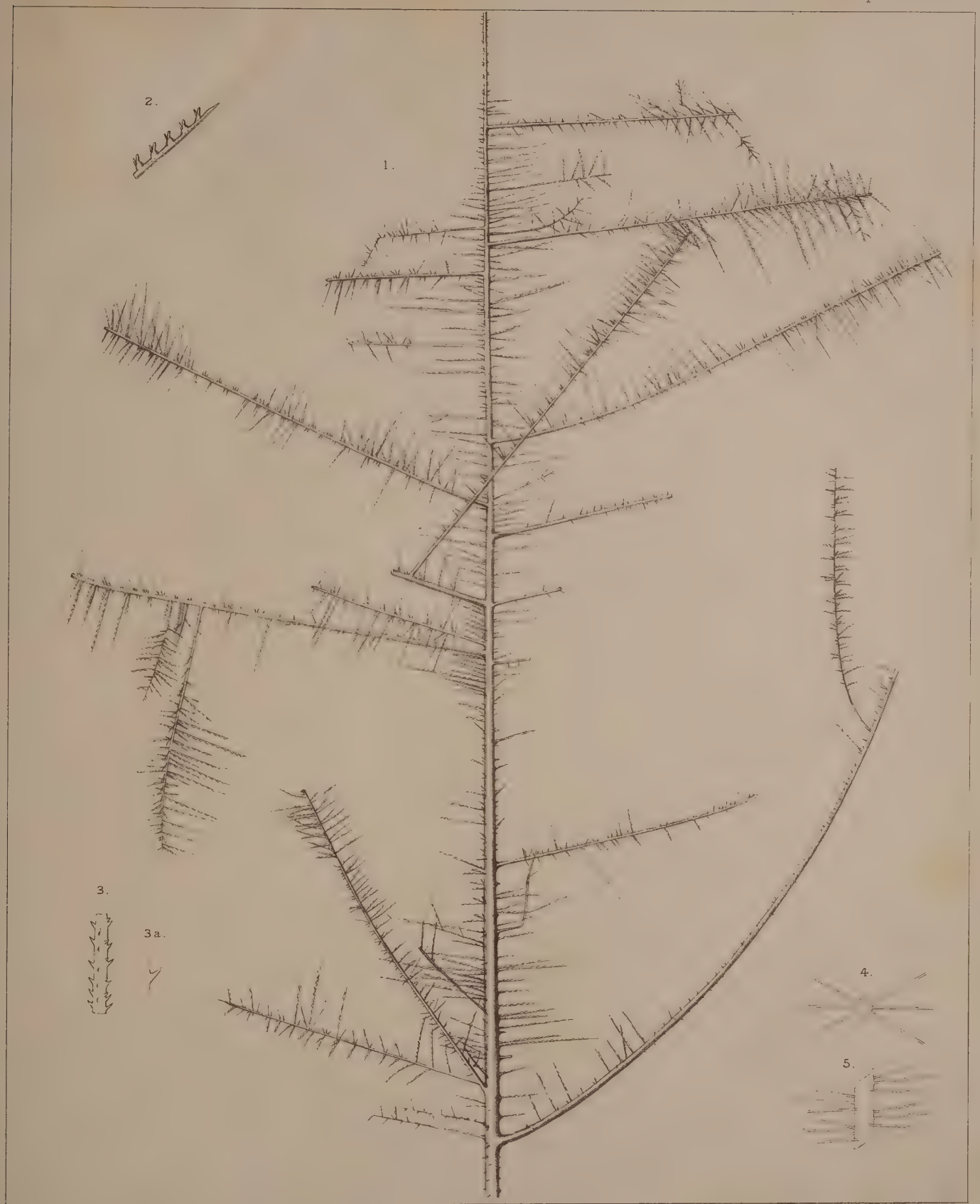


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PLATE VIII.

PLATE VIII.

Schizopathes crassa, n. sp.

Diam.

Fig. 1. The type specimen; one-third natural size.

Fig. 2. Portion of a branch, showing the arrangement of the dimorphic zooids, as seen from the side; natural size.

Fig. 3. The same portion, seen from above, ... × 3

Fig. 4. The sickle-shaped base seen in profile; natural size.

Fig. 5. Portion of a branch, showing the arrangement of the spines, . × 13

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PLATE IX.

PLATE IX.

Figs. 1–6. *Schizopathes affinis*, n. sp.

Diam.

Fig. 1. The whole corallum, showing isolated degenerate zooids on the lower portion of each branch; one-half natural size.

Fig. 2. Apical portion of a branch, bearing crowded dimorphic zooids above and more isolated ones below, ... × 2

Fig. 3. Two triplets of dimorphic individuals, seen from above, showing the mouth in each gastrozooid, ... × 4

Fig. 4. Portion of a branch, showing the arrangement of the spines, . . × 13

Fig. 5. Sickle-shaped base of the corallum, seen from the side, . . × 2

Fig. 6. Middle portion of a sickle-shaped base, showing three rows of acute spines, ... × 9

Figs. 7–10. *Bathypathes alternata*, n. sp.

Fig. 7. Outline of a specimen attached to a stone; one-half natural size.

Fig. 8. Apical portion of the corallum, bearing isolated dimorphic zooids; natural size.

Fig. 9. Portion of a branch, showing the position of the zooids, . . × $2\frac{1}{2}$

Fig. 10. Portion of a branch, showing the arrangement of the spines, . × 13

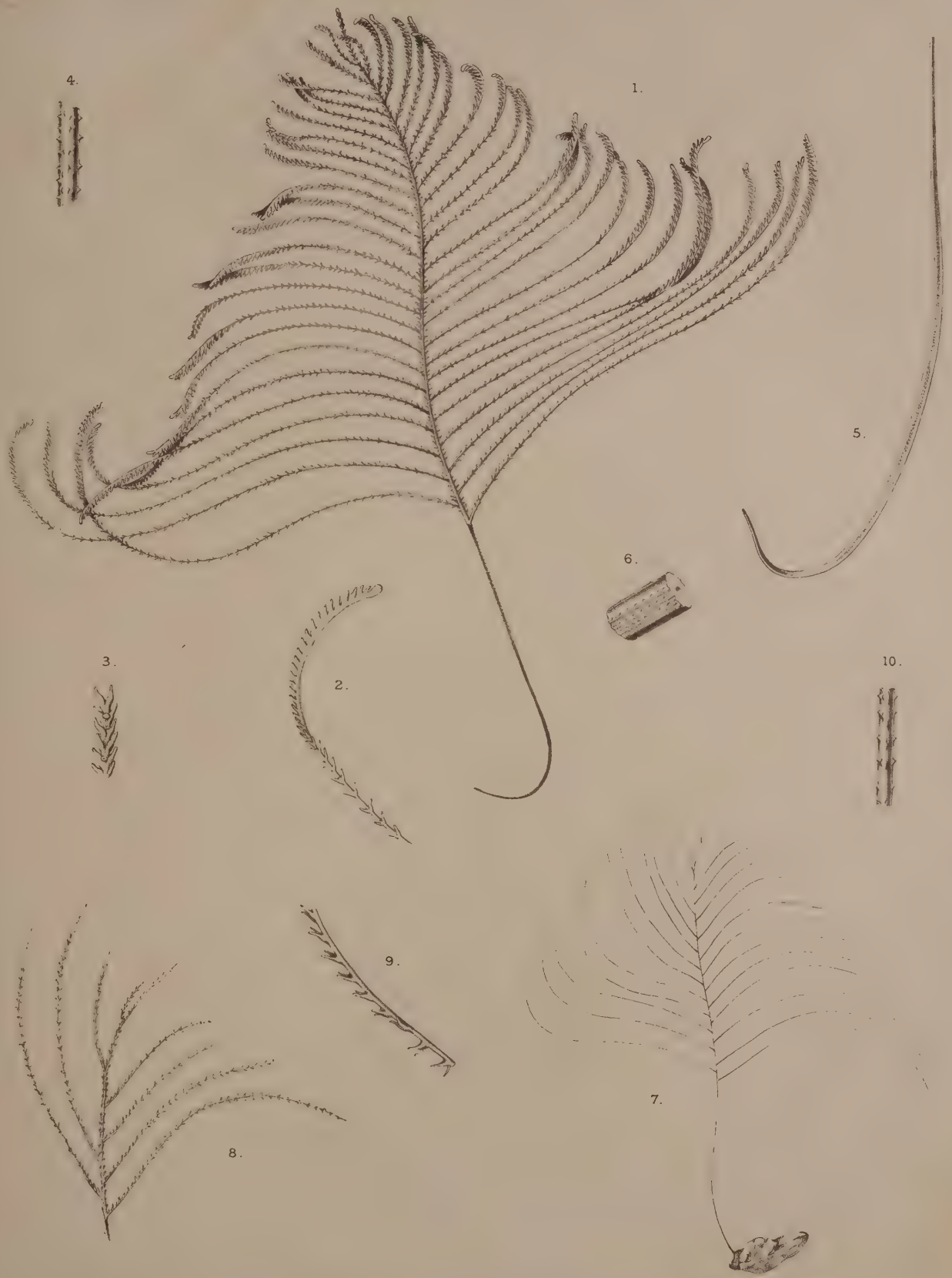

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PLATE X.

PLATE X.

Figs. 1–8. *Dendrobrachia fallax*, n. sp.

Diam.

Fig. 1. Portion of the corallum, showing the mode of branching; natural size.

Fig. 2. Apical portion of a branch, showing the position of the polyps; natural size.

Fig. 3. Portion of a branch, bearing one polyp, ... × 13

Fig. 4. A single pinnate tentacle, ... × 13

Fig. 5. Portion of the sclerenchyma, showing the spinose rugæ, . . × 13

Fig. 6. Transverse section of the sclerenchyma near the apex of a branch, . × 26

Fig. 7. A similar section taken near the middle of a branch, . . × 13

Fig. 8. Transverse section taken near the base of a branch, . . × 6

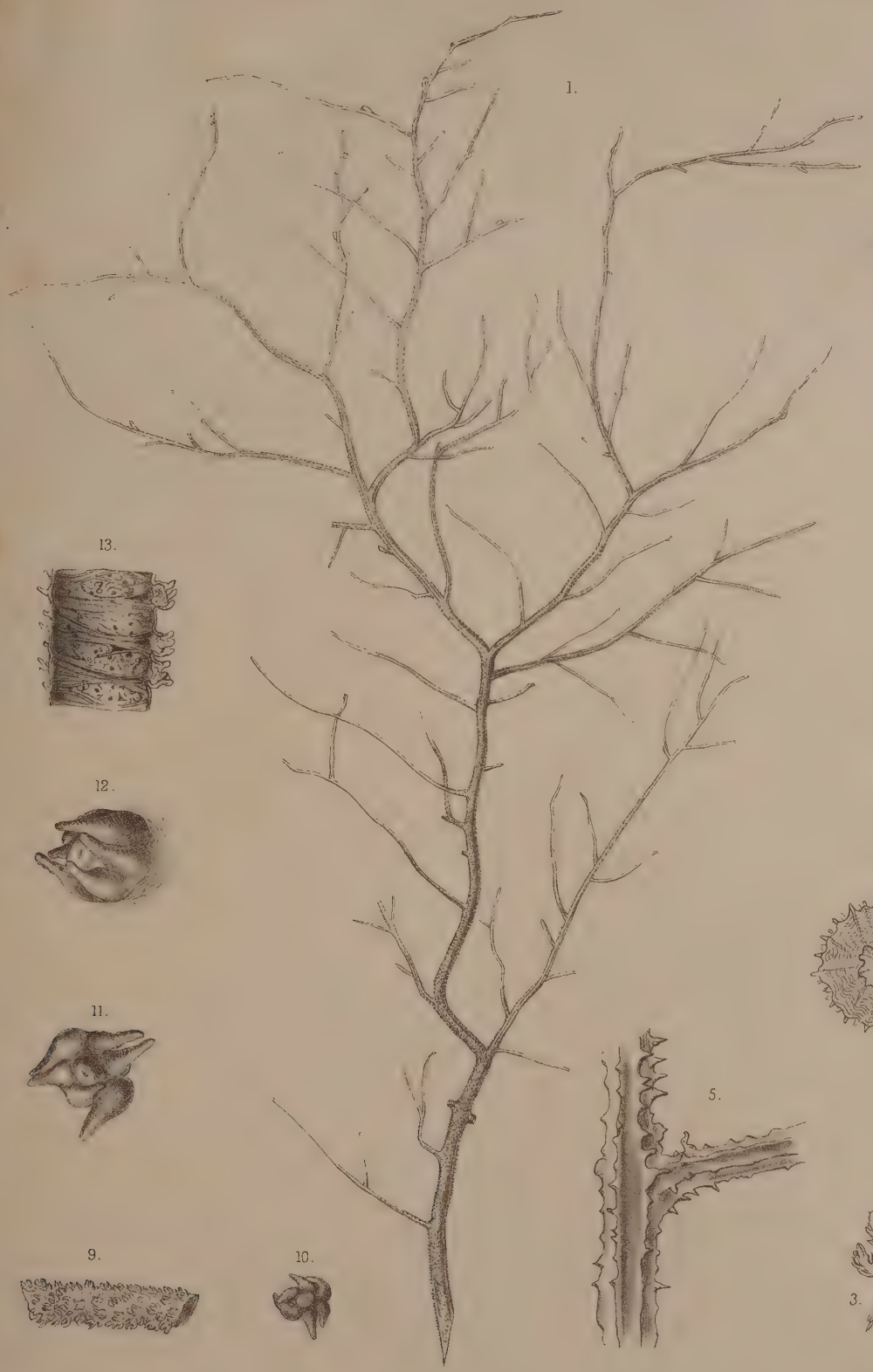
Figs. 9–13. *Cirripathes propinqua*, n. sp.

Fig. 9. Portion of the stem clothed with polyps and cœnenchyma; natural size.

Fig. 10. A single polyp, seen from above, ... × 4

Figs. 11, 12. Two other individuals, ... × 7

Fig. 13. View of the inner surface of the skeletal sheath, showing the transverse mesoglœal septa in the cœnenchyma, . . . × 5



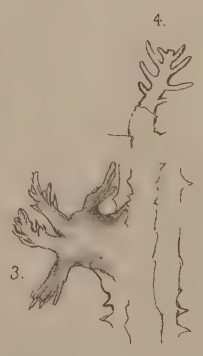


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PLATE XI.

PLATE XI.

Arrangement of Spines.

		Diam.
Fig. 1.	*Parantipathes hirta* (Gray), ... ×	26
Fig. 2.	*Antipathes furcata* (Gray), ... ×	26
Fig. 3.	*Aphanipathes alata*, n. sp., ... ×	26
Fig. 4.	,, *barbadensis*, n. sp., ... ×	26
Fig. 5.	[*Antipathes*] *ulex*, E. and S., ... ×	26
Fig. 6.	*Aphanipathes wollastoni* (Gray, MS.), ... ×	26
Fig. 7.	,, *fruticosa* (Gray), ... ×	26
Fig. 8.	*Antipathella gracilis* (Gray), ... ×	26
Fig. 9.	*Antipathes mediterranea*, n. sp., ... ×	26
Fig. 10.	*Arachnopathes clathrata ?* . . . . . ×	26
Fig. 11.	,, *aculeata*, n. sp., ... ×	26
Fig. 12.	*Aphanipathes pedata* (Gray), ... ×	26
Fig. 13.	*Antipathes virgata*, Esper, ... ×	26
Fig. 14.	,, ,, ,, ... ×	26
Fig. 15.	*Tylopathes dubia*, n. sp., ... ×	26
Fig. 16.	,, *elegans*, n. sp., ... ×	26
Fig. 17.	[*Antipathes*] *pumila*, n. sp., ... ×	26
Fig. 18.	*Tylopathes flabellum* (Pall.), ... ×	26
Fig. 19.	*Antipathes lentipinna*, n. sp., ... ×	26
Fig. 20.	[*Antipathes*] *bifaria*, n. sp., ... ×	26
Fig. 21.	,, *abies* (Linn.), Gray, ... ×	26
Fig. 22.	*Arachnopathes ericoides* (Pall.), ... ×	26
Fig. 23.	*Aphanipathes pennacea* (Pall.), ... ×	26
Fig. 24.	[*Antipathes*] *spinescens*, Gray, ... ×	26
Fig. 25.	,, *japonica*, n. sp., ... ×	26

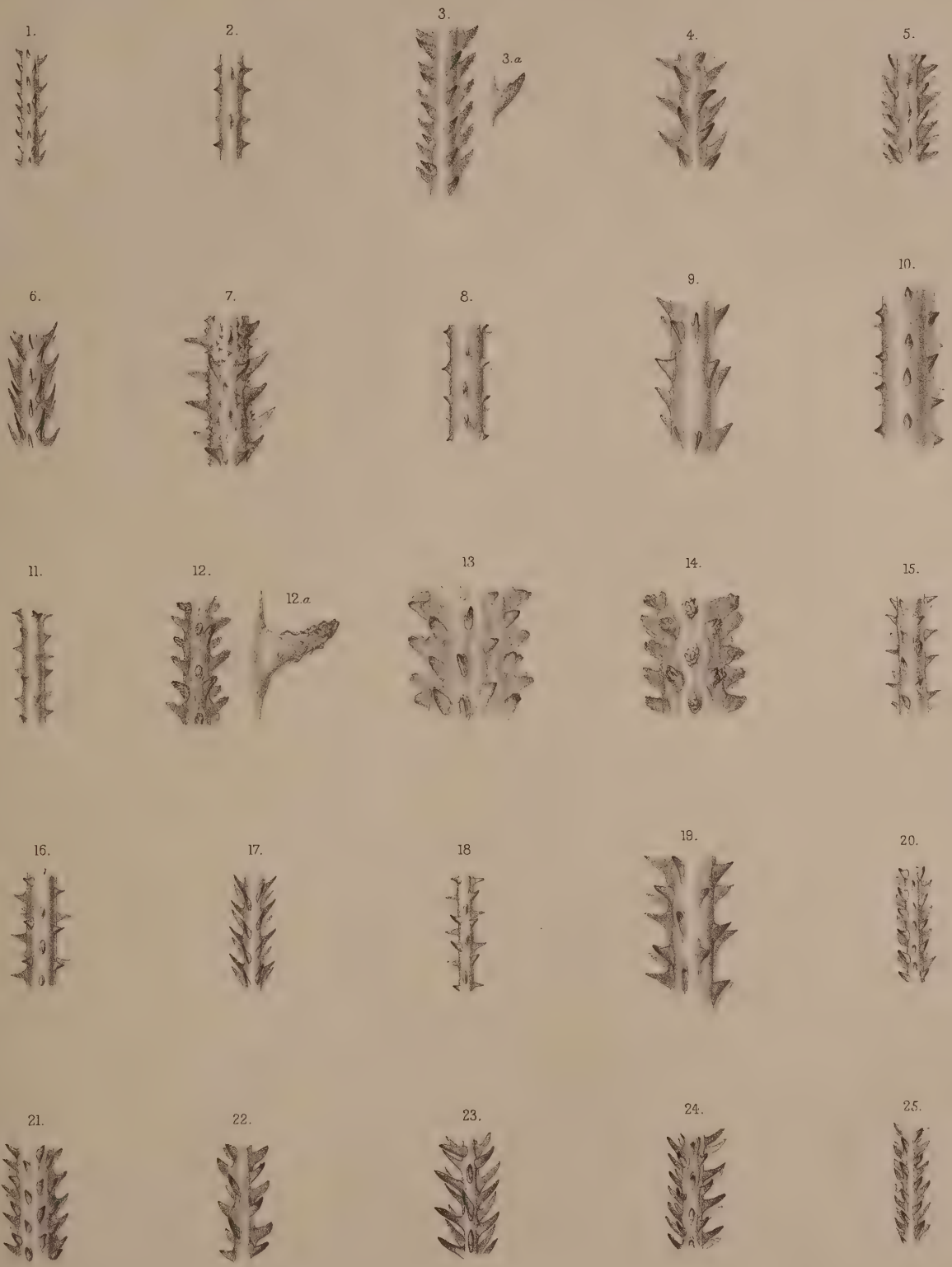

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PLATE XII.

PLATE XII.

Arrangement of Spines.

			Diam.
Fig. 1.	[*Antipathes*] *myriophylla*, Pallas,	×	26
Fig. 2.	*Antipathella intermedia*, n. sp.,	×	26
Fig. 3.	„ *reticulata* (Pall.),	×	26
Fig. 4.	*Tylopathes hypnoides*, n. sp.,	×	26
Fig. 5.	*Antipathella atlantica* (Gray),	×	26
Fig. 6.	*Cirripathes paucispina*, n. sp.,	×	8
Fig. 7.	*Stichopathes occidentalis* (Gray), near the apex of the stem,	×	8
Fig. 8.	„ „ „ near the base,	×	8
Fig. 9.	„ *echinulata*, n. sp.,	×	8
Fig. 10.	*Cirripathes spiralis* (Pall.),	×	8
Fig. 11.	*Antipathella strigosa*, n. sp.,	×	26
Fig. 12.	*Cirripathes diversa*, n. sp.,	×	8
Fig. 13.	„ *flagellum*, n. sp. (only half the stem is shown),	×	12
Fig. 14.	„ *propinqua*, n. sp. (only half the stem is shown),	×	12
Fig. 15.	*Antipathella subpinnata* (E. and S.),	×	26
Fig. 16.	*Antipathes dichotoma*, Pallas,	×	26
Fig. 17.	*Stichopathes gracilis* (Gray), near the apex of a stem,	×	8
Fig. 18.	„ „ „ near the middle of a stem,	×	8
Fig. 19.	„ „ „ near the base,	×	8
Fig. 20.	*Parantipathes larix* (Esper),	×	26
Fig. 21.	*Leiopathes glaberrima* (Esper),	×	26
Fig. 22.	„ „ „	×	26
Fig. 23.	*Stichopathes filiformis* (Gray),	×	8
Fig. 24.	„ „ „	×	8
Fig. 25.	*Aphanipathes verticillata*, n. sp.,	×	26
Fig. 26.	[*Antipathes*] *arctica*, Lütken,	×	26
Fig. 27.	*Antipathella boscii* (Lamx.),	×	26
Fig. 28.	*Stichopathes lütkeni*, n. sp.,	×	26

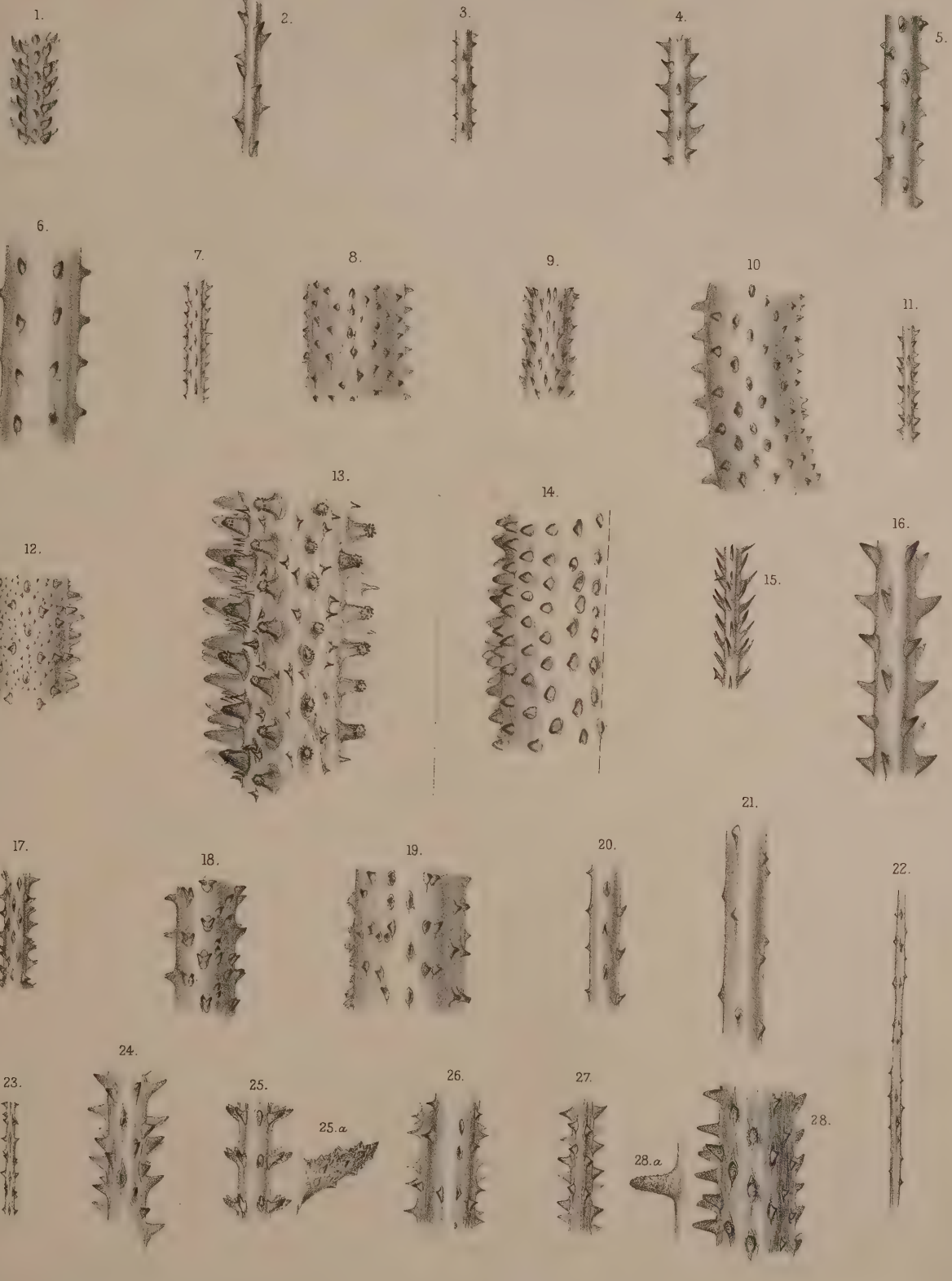

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PLATE XIII.

PLATE XIII.

a.e. Axis epithelium.
b. Fibrous layer of ectoderm.
c. Cœnenchyma.
d. Small gland cells of stomodæal ectoderm.
e. Entodermal epithelium.
ec. Ectoderm.
en. Entoderm.
f. Muscular layer.
g^1. Ectodermal gland cells.
g^2. Entodermal gland cells.
ga. Ganglion.
g.c. Germinal cells.
k. Sperm polyplasts.
l. Spermatozoa.
m^1. Primary mesentery.
m^2. Secondary mesentery.
me. Mesoglœa.
m.f. Mesenterial filament.
n. Nematocysts.
n.l. Nervous layer.
o. Ova.
o^1. Young ova.
p. Papillæ of ectoderm.
s. Stomodæum.
sc. Sclerenchyma.
sc^1. Lumen of sclerenchyma.
sep. Interzooidal septum.
sep^1. Septum uniting the mesoglœa of the skeletal sheath with that of the cœnenchyma.
sp. Spine.

Diam.

Fig. 1. Polyps of *Antipathes dichotoma*, Pallas, ... × 8

Fig. 2. Two polyps of *Parantipathes larix* (Esper), ... × 8

Figs. 3–8. *Antipathella subpinnata* (E. & S.).

Fig. 3. Polyps, showing the mouth contracted, ... × 8

Fig. 4. Three polyps with the mouth widely open, showing the crenate inner margin and the elongate stomodæum beneath, . . × 8

Fig. 5. Vertical longitudinal section of a polyp passing through a portion of the skeletal sheath, ... × 75

Fig. 6. Sagittal section of a polyp passing through the extreme elongation of the stomodæum, ... × 75

Fig. 7. Subhorizontal section passing through the middle of the stomodæum, × 75

Fig. 8. Longitudinal section of a portion of the wall of the tentacle (borax-carmine preparation), ... × 340

Fig. 9. *Antipathes dichotoma*, Pallas. Longitudinal section of the ectoderm of a tentacle passing through the middle of the papillæ (borax-carmine preparation), ... × 330

Fig. 10. *Antipathella subpinnata* (E. & S.). Vertical section of the wall of the stomodæum (borax-carmine preparation), . . . × 700

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PLATE XIV.

PLATE XIV.

a.e. Axis epithelium.
b. Fibrous layer of ectoderm.
c. Cœnenchyma.
d. Small gland cells of stomodæal ectoderm.
e. Entodermal epithelium.
ec. Ectoderm.
en. Entoderm.
f. Muscular layer.
g^1. Ectodermal gland cells.
g^2. Entodermal gland cells.
ga. Ganglion.
g.c. Germinal cells.
k. Sperm polyplasts.
l. Spermatozoa.
m^1. Primary mesentery.
m^2. Secondary mesentery.
me. Mesoglœa.
m.f. Mesenterial filament.
n. Nematocysts.
n.l. Nervous layer.
o. Ova in figs. 1 and 7; spermatic capsules in fig. 4.
o^1. Young ova.
p. Papillæ of ectoderm.
s. Stomodæum.
sc. Sclerenchyma.
sc^1. Lumen of sclerenchyma.
sep. Interzooidal septum.
sep^1. Septum uniting the mesoglœa of the skeletal sheath with that of the cœnenchyma.
sp. Spine.

Diam.

Fig. 1. *Antipathes dichotoma*, Pallas. Portion of a vertical longitudinal section, showing the position of the ovary, ... × 75

Fig. 2. *Aphanipathes sarothamnoides*, n. sp. Subhorizontal section of a polyp, showing the spines penetrating the zooidal tissues, . . × 65

Fig. 3. *Aphanipathes sarothamnoides*, n. sp. Transverse section of the sheath of tissue which surrounds a spine, ... × 300

Fig. 4. *Pteropathes fragilis*, n. sp. Subhorizontal section of a polyp, showing the convoluted stomodæum, ... × 75

Fig. 5. *Antipathes dichotoma*, Pallas. Longitudinal section of the ectoderm of a tentacle (borax-carmine preparation), ... × 400

Fig. 6. *Antipathes dichotoma*, Pallas. Section of the base of a polyp (cœnenchyma), ... × 400

Fig. 7. *Cirripathes propinqua*, n. sp. Section of two polyps and two interzooidal areas, showing the interzooidal septa in transverse section, ... × 37

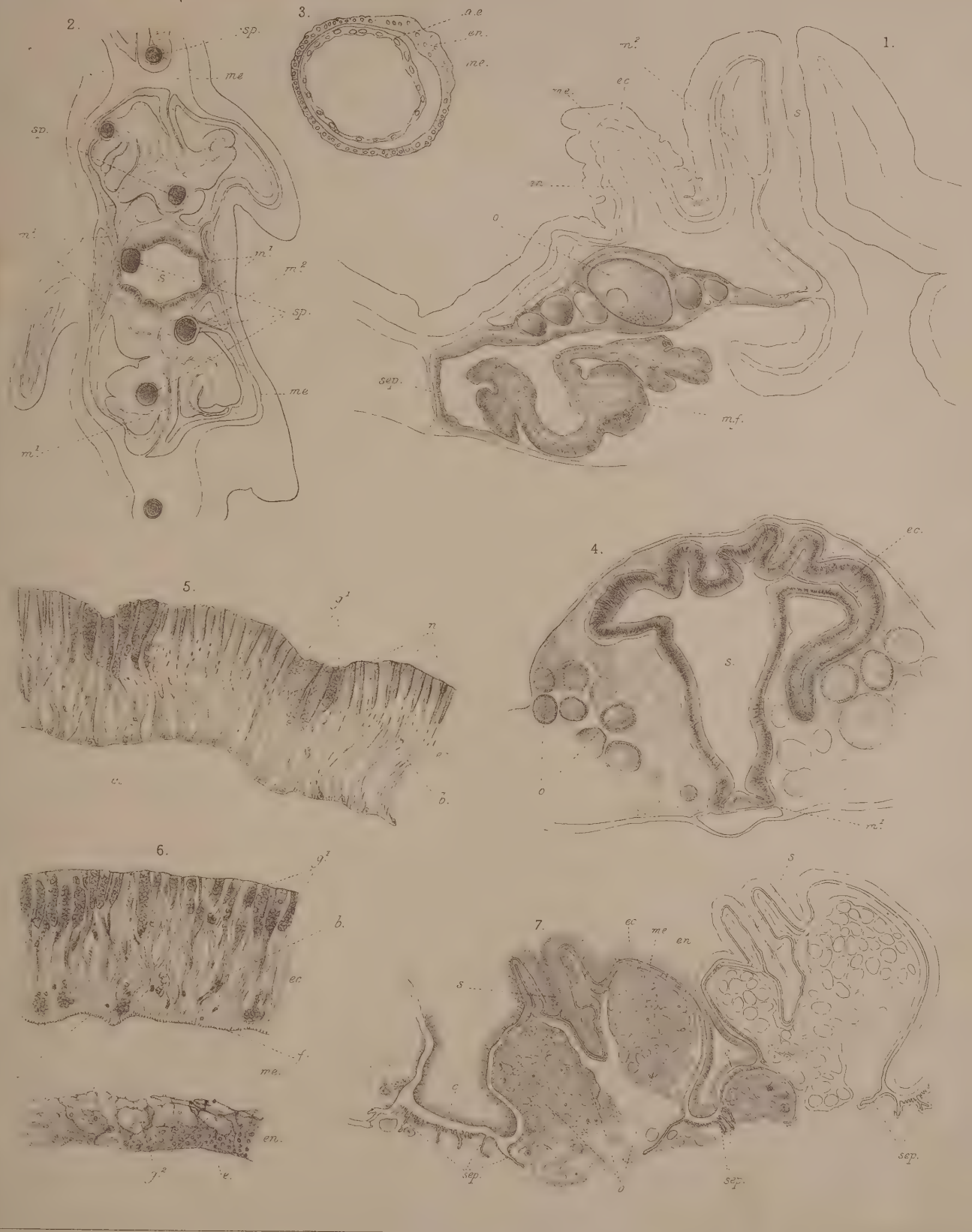

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PLATE XV.

PLATE XV.

a.e. Axis epithelium.
b. Fibrous layer of ectoderm.
c. Cœnenchyma.
d. Small gland cells of stomodæal ectoderm.
e. Entodermal epithelium.
ec. Ectoderm.
en. Entoderm.
f. Muscular layer.
g^1. Ectodermal gland cells.
g^2. Entodermal gland cells.
ga. Ganglion.
g.c. Germinal cells.
k. Sperm polyplasts.
l. Spermatozoa.
m^1. Primary mesentery.
m^2. Secondary mesentery.
me. Mesoglœa.
m.f. Mesenterial filament.
n. Nematocysts.
n.l. Nervous layer.
o. Ova.
o^1. Young ova.
p. Papillæ of ectoderm.
s. Stomodæum.
sc. Sclerenchyma.
sc^1. Lumen of sclerenchyma.
sep. Interzooidal septum.
sep^1. Septum uniting the mesoglœa of the skeletal sheath with that of the cœnenchyma.
sp. Spine.

Diam.

Fig. 1. *Parantipathes larix* (Esper). Vertical transverse sections of a polyp; the right half of the figure passes through the base of a lateral tentacle; the left half represents a section nearer the median transverse axis, ... × 108

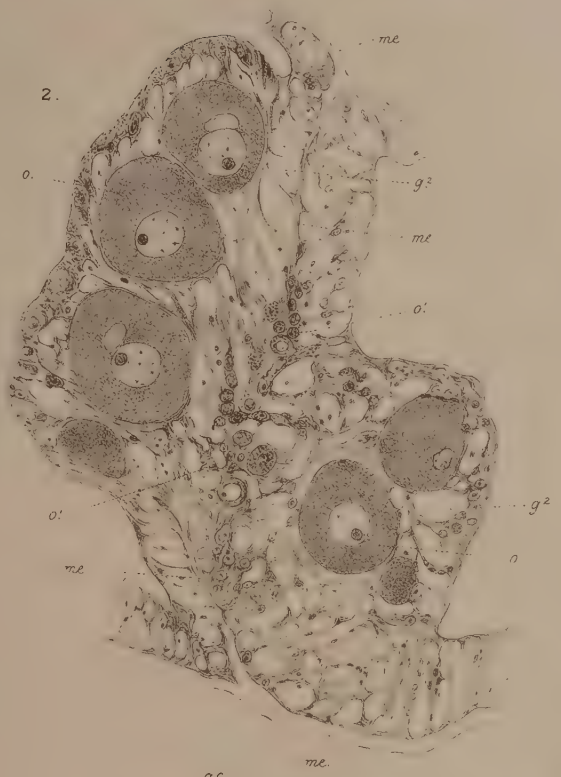
Fig. 2. *Antipathella subpinnata* (E. & S.). Horizontal section of a transverse mesentery, showing the position of the ova, . . . × 300

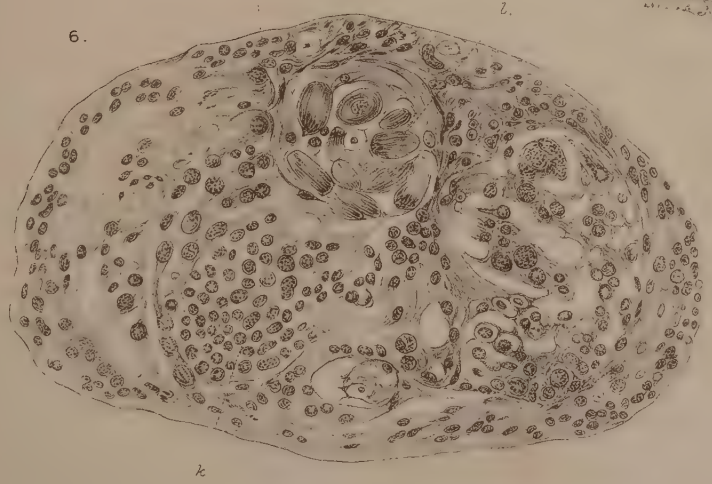
Fig. 3. *Leiopathes glaberrima* (Esper). Longitudinal section of the wall of a tentacle, ... × 560

Fig. 4. *Leiopathes glaberrima* (Esper). Vertical section of a rather young polyp, ... × 47

Fig. 5. *Leiopathes glaberrima* (Esper). Vertical section of the mesenterial filaments shown in the right half of fig. 4, ... × 250

Fig. 6. Transverse section of the vermiform parasite from the cœlenteron of *Antipathella subpinnata* (E. & S.), ... × 450





F. Huth, Lith^r Edin^r

THE

VOYAGE OF H.M.S. CHALLENGER.

ZOOLOGY.

SUPPLEMENTARY REPORT on the ALCYONARIA collected by H.M.S. Challenger during the Years 1873–76. By Professor TH. STUDER, M.D., Bern.

PREFACE.

AFTER the main Report on the Challenger Alcyonaria was in the press, several further specimens were found. These were in part new species, of which, however, it was no longer possible to insert a description in the text. I am under great obligations to Dr. John Murray, the editor of the Challenger Reports, for allowing me to publish in the form of a Supplement an account of these new species with the necessary illustrations. At the same time I have seized the opportunity to insert further illustrations of such forms as Dr. Wright and myself had only been able to describe in the Report, as *Telesto trichostemma* and *Siphonogorgia köllikeri*.

This Supplement extends the list of the Challenger collection by three new species of the genus *Siphonogorgia*, three Muriceidæ, an Indian representative of the genus *Bebryce* (which before had been known only from the Mediterranean), and one of the Plexauridæ.

Order I. ALCYONACEA, Verrill.

Family CORNULARIDÆ, Dana.

Telesto, Lamouroux.

Telesto, Lamouroux, Bull. Soc. Philom. Paris, 1812; Hist. d. Polyp. flexib., p. 252, 1816.

Subgenus *Carijoa*, F. Müller.

Carijoa, F. Müller, Archiv f. Naturgesch., Jahrg. xxxiii. p. 330, 1867.

Telesto (*Carijoa*) *trichostemma* (Dana) (Pl. III. figs. 1*a*, 1*b*; Pl. V. fig. 1; Pl. VI. figs. 1, 2).

Telesto (*Carijoa*) *trichostemma*, Chall. Report, Alcyonaria, Zool. Chall. Exp., part lxiv. p. 264.
Gorgonia trichostemma, Dana, Zooph., p. 665.

The description of this interesting species was given in the former report upon the Alcyonaria of the Challenger collection. This, after further research, I would now complete, and elucidate by means of several illustrations.

The most striking characteristic of the species is the peculiar construction of a kind of inner skeleton, such as is commonly to be met with in *Tubipora*. The spicules surrounding the elongated digestive cavities of the primary and secondary axial polyps lie in such intimate contact with one another that, in the older parts of the colony, they form a continuous calcareous cylinder. Towards the base this is further strengthened by the horny substance secreted between the spicules.

If this calcareous tube be isolated by maceration, or by treatment with caustic potash, it persists as a connected structure, composed of a very fine, almost sponge-like, calcareous substance having the form of the polyps. Its outer wall is marked with eight furrows, between which arise an equal number of longitudinal ribs. The associated tubes of the axial polyps of the second order are short, and seated upon the main axis like the calyces of a Madrepore. The cavity does not communicate with that of the main tube, but is separated from it by a delicate spongy calcareous lamella. In transverse sections of the older primary polyps of the stem, eight slightly-developed mesenteric folds may be seen to project into the cavity of the tube; their mesoderm contains no spicules; the inner wall is covered with a cylindrical epithelium, which, on certain parts of the preserved specimen, may be still seen to be equipped with cilia. To the outside of this follows a thin structureless mesodermic layer, which becomes thicker at a mesenteric fold into which it enters. Further to the outside is the zone of spicules. These are arranged, in part, longitudinally, in part towards the periphery; together they form a network. They do not, however, fuse together, but are only interlocked by their spines.

In this way they build up a connected whole, which, when isolated, forms a tube. The spicules are thickest in the inner layer, being quite loose towards the outside. The ectoderm is only distinguishable in a few places, when it appears as a layer of cylindrical cells. For the most part it has been destroyed and penetrated by the tissue of a siliceous sponge, which covers the whole colony, even spreading itself over the smaller secondary polyps. In the lower portion it develops in considerable thickness, and deforms, in a remarkable manner, the habit of the whole colony, so that the lateral polyps look as if they were pressed against the stem.

The longitudinal ribs which mark the wall of the axial and secondary polyps are due to a thickening of the middle spicule-bearing layer. Their position is always between two mesenteric folds, while the intermediate furrows correspond in position to the same. Nutritive canals and endodermic tubes are not demonstrable in the older portions of the axial polyps. These first appear where the net of spicules becomes loose, and are finally lost in isolated calcareous bodies; there they unite the secondary polyps with the cavities of the axial polyps.

Along with the foregoing description of this species it should be mentioned that, in those parts of the colony which are free from the parasitic sponge, the lateral polyps appear tubular, and stand free from the axial polyps at an acute angle. They exhibit longitudinal striation, and reach a length of from 2·5 to 4 mm., with a breadth of from 1 to 1·5 mm.

Family Alcyonidæ, Verrill.

Sarakka, Danielssen.

Sarakka, Danielssen, Norske Nordhavs-Exped., 1876–78, Zoolog., Alcyonida, p. 118, 1887.

Sarakka crassa, Danielssen, *loc. cit.*, p. 112.

A small polyp colony in the Challenger collection agrees so exactly with Danielssen's excellent figure and description, that I identify it, without doubt, as belonging to this species. From a broad lobed base, growing upon foreign bodies, the colony attains a height of about 16 mm., dividing into two thick branches, from which short lobed twigs are given off, thickly beset with polyps at their ends. Stem and branches are hard and rigid, with longitudinal grooves.

The colour, in spirit, is yellowish white. The form of the polyps and of the spicules agrees, in all particulars, with Danielssen's description.

Habitat.—Stations 135 A–C; off Tristan da Cunha; 100 to 550 fathoms; hard ground, shells, gravel.

Danielssen's specimen was obtained by the North Atlantic Expedition at Station 31; lat. 63° 10′ 5″ N., long. 5° E.; 417 fathoms; bottom, sandy clay.

Family Nephthyidæ.

Subfamily Siphonogorginæ.

Siphonogorgia, Kölliker.

Three more species of this interesting genus were subsequently found among the Challenger gatherings; these extend the compass of the genus to seven species. The examination of these specimens fully confirms the formerly expressed opinion that the genus

should be included within the family Nephthyidæ, for, in spite of an external appearance widely different from *Spongodes* and *Nephthya*, which is expressed in the Gorgonid-like habit, the inner structure of the colony corresponds closely with that of the above-mentioned family. Its higher and more slender growth necessitates an increase in the strength of the colony; this has been given to it by means of a considerable development of its spicular network in the walls of the polyp tubes.

As in *Spongodes*, the branches and twigs consist of bundles of polyp tubes, four, or sometimes five, in number, terminating in the polyp heads at the end of each twig.

The tubes, consisting of thick mesodermic walls, communicate with each other by means of delicate endodermic nutritive canals. The walls of the tubes meet in the axes of the twigs so that the individual digestive cavities of the polyps are arranged around a kind of axis in a radial fashion. Fresh buds from the sides of the polyp walls arise from the system of the nutritive canals, so that in cross section their digestive cavities are always exterior to the four main canals. Also there may be distinguished, in the larger stems, four or five broader tubes in the centre, separated from one another by thick cœnenchyma. This investing cœnenchymatous layer is filled with large spicules arranged parallel to the longitudinal axis. To the outside of these there are additional longitudinal canals of various diameters, which communicate with one another, as also with the broader central canals, in a network of nutritive canals. To the outside of this network is a continuous layer of these longitudinally arranged spicules (see Pl. VI. fig. 5).

From without inwards, then, the stem consists of—

(1) Ectoderm, as a thin layer of flattened cells.
(2) A layer of large spicules.
(3) A circle of polyp tubes.
(4) Thick cœnenchyma containing large spicules.
(5) Four or five wide central canals, the walls of which are in contact in the centre.

The polyps, in the greater number of species, consist of a calycine portion into which the alimentary and tentacular parts of the polyp may be withdrawn. On the tentacular portion is a collar of spicules arranged in a circle, and, outside of these, spicules, arranged *en chevron*, which strengthen the base of the tentacle. The spicules are continued up to the apex of the tentacle. In rest the tentacles are folded together over the mouth of the polyp.

In one species, *Siphonogorgia pendula*, n. sp., the anterior portion of the polyp can be withdrawn into the bilateral calyx only as far as the collar; the oral region, with the spicule-bearing and folded tentacles, remains outside the calyx. In this respect the form of the polyps agrees entirely with that of the polyps in *Spongodes*.

As far as our present knowledge extends, the species of the genus *Siphonogorgia* are confined to the Indo-Pacific region. The following species are those at present known:—

Siphonogorgia squarrosa, Kölliker and Studer, .	West Australia.
,, *pendula*, n. sp., . . .	Bay of Amboina.
,, *mirabilis*, Klunzinger, . .	Red Sea, Arafura Sea, North-west Australia.
,, *köllikeri*, Wright and Studer, . .	Bay of Amboina.
,, *pustulosa*, n. sp., . . .	Off Api, New Hebrides.
,, *pallida*, n. sp., . . .	Admiralty Islands.
,, *godeffroyi*, Kölliker, . . .	Pelew Islands.

Siphonogorgia pendula, n. sp. (Pl. I. figs. 1*a*, 1*b*; Pl. V. fig. 2).

The stem is erect and branched, finally dividing into thin twigs, which are less rigid than the larger ones, and bend towards the base of the stem. The apices of the twigs are beset with polyps, of which the oral region is not completely retractile, so that the collar, along with the infolded tentacles, lies over the orifice of the bilateral calyx.

The main stem is for the most part torn away from its basis, only a part of which is to be seen as a membranous expansion over the surface of a sponge. Near the base the stem measures 11 mm. in diameter; rising in a somewhat curved course, it becomes gradually thinner. The points of the stem and of the twigs have been broken off, so that it is difficult to reconstruct the entire form from the many broken fragments that are to hand. The stem has a diameter of 7 mm. at a height of 20 cm., where it has been broken. The thicker branches, 5 to 6 mm. in diameter at the base, arise, with one exception, from the convex side of the stem, the lowest twig alone springing from the opposite side at a level of 70 mm. The chief branches form, with the stem, angles of 30° to 45°. From these branches secondary branches may be produced, upon the ends of which there arise at first, slender, erect, and flexible twigs, thickly beset with polyps. These twigs may attain a length of 20 to 30 mm., with a thickness of 2 to 3 mm. They frequently bear secondary twigs in addition to the polyps. The slender ends of the branches, and also, possibly, of the stem, have the character of the terminal twigs, and are studded with polyps.

Whilst the naked main axis and the branches appear smooth on the surface, and uniformly rounded, their form changes from the point at which the polyp-bearing twigs arise. They become more or less flattened, chiefly where the twigs are given off, and show deep furrows, giving the stem a grooved character. At the extremity of the twig is a cluster of four polyps; over the remaining portion the polyps are distributed in spirals, the intervals between the individuals composing such being greater towards

the base than towards the apex. The very short twigs are thickly studded with polyps, the spirals being in very close proximity. The polyps themselves form heads which have a great resemblance to those of *Spongodes*. They are 1·5 mm. high, and 0·8 mm. in diameter. In each polyp-head is a calyx portion, formed of rough spindle-shaped spicules. Into this the oral region of the polyp cannot be withdrawn, but it lies with the collar upon the margin of the cup. The calyx is attached obliquely to the twig; its outer wall is the higher, the spicules there projecting somewhat beyond the oral region of the retracted polyp, in a spinous fashion.

On the oral region may be distinguished a broad collar, composed of a ring of spicules. Above these are eight pairs of large spicules with their points converging towards the ends of the tentacles. These are imbedded in the base of the tentacles, for which, when folded, they form a protection.

The spicules are in general spindle-shaped, and covered with warty protuberances. The large spicules of the outer layers of the stem and branches are sometimes straight, sometimes curved, or approximately *ſ*-shaped. They are covered with warts ending in delicate spines. Their dimensions are 2·8 by 0·224 mm.; 1·82 by 0·198 mm.; 0·91 by 0·098 mm. In the thicker branches they lie irregularly in a thick layer. In the thinner twigs they form longitudinal rows, being arranged parallel to the axis; they also become more slender, and are in part beset only with the delicate spines.

Long spindles also occur, especially in the angles formed by the secondary twigs; they attain a length of 2·24 mm., and a breadth of 0·154 mm. Others have dimensions of 1·014 by 0·112 mm.; 0·91 by 0·098 mm.

The spicules of the calyx are thick, and covered with blunt warts, spindle-shaped, straight, or slightly curved; dimensions 1·27 by 0·624 mm. Those of the collar are slender, slightly curved, blunt at one end and pointed at the other, bearing sharp thorns; dimensions 0·56 by 0·04 mm.

The cover of the tentacles is composed of similarly formed, somewhat more markedly curved, spicules; dimensions 0·38 by 0·021 mm. The spicules which line the walls of the inner canals are, in part, long, club-shaped, but commonly straight, and more or less rounded at their extremities, bearing small sharp spines; dimensions 0·952 by 0·06 mm. In addition there occur fine, small, spindle-shaped bodies, with sharp erect spinules; dimensions 0·14 by 0·03 mm.; 0·168 by 0·03 mm.

The colour of the colony appears of a coral-red, with a tint of violet, polyp heads white. The spicules of the stem and of the branches are in part dark purplish red, in part pale rose, at times white. Those in the neighbourhood of the four larger stem canals are white.

Habitat.—Bay of Amboina.

Siphonogorgia köllikeri, Wright and Studer (Pl. I. fig. 2; Pl. V. fig. 3; Pl. VI. figs. 4, 5).

Siphonogorgia köllikeri, Wright and Studer, Zool. Chall. Exp., part lxiv. pp. 236, 276.

Another perfect specimen of this species was found amongst a number of corals collected in the Bay of Amboina. The dark red colony suggests in its appearance the precious coral. It is 45 mm. high, spreading itself out from a short thick stem in five branches lying in one plane, from which branches side twigs are given off at an obtuse angle. The branches and twigs are rounded at their ends, bearing usually four polyps. The other polyps spring chiefly from two sides of the somewhat flattened branches and twigs at some distance apart from one another. The calyces are large, blunt, cone-shaped, arising directly from the base of the branch. The whole colony is rigid and brittle, owing to the presence of the numerous large spicules.

Habitat.—Bay of Amboina.

Siphonogorgia pustulosa, n. sp. (Pl. II. figs. 1*a*, 1*b*; Pl. V. fig. 4).

From a broad lobed base, which covered a piece of coral breccia, rises in a sinous course a main axis, giving off branches at an angle of about 45°; these, from two sides in the same plane, give rise to secondary branches and twigs. The polyps are spirally arranged, their calyces standing out, like yellow pustules on the coral-red ground of the branches. The cœnenchyma is smooth.

Unfortunately the two specimens are both broken so that the whole extent of the colony cannot be determined. In one specimen the stem is 6 mm. thick at its lower extremity. At a height of 49 mm. is a branch 5 mm. thick which bears on two sides secondary branches 3 to 4 mm. in thickness. These are always produced at the base of a branch from its under side, so that they have a bent course. The twigs are 3 mm. thick at their extremities and are somewhat flattened. The main branches are 90 mm. in length, the smaller reach 21 mm.

The polyps are borne even upon the main axis; on the branches and twigs they are arranged in a spiral at intervals of 2 mm. The end of each twig bears four or five polyps clustered together. The low conical calyces are erect, and have a diameter of 1 mm. The oral region of the polyp is retracted as far as the margin of the folded tentacles, but the margin of the calyx does not close over them, so that the star which is formed by the tentacular lid can be seen from above.

The canal system communicates with four central stem canals; these are separated by relatively thin septa, in which dark red spicules are embedded. Round these lies a very thick cortex, beset with spicules, which in a branch of 4 mm. has a thickness of 1·5 mm.

The spicules of the cœnenchyma are again large, and lie very irregularly on the stem and larger branches. In the smaller twigs they lie longitudinally. They are spindle-shaped, often straight, often more or less curved, sometimes thickened at each extremity. They are thickly beset with rough warts, which lie closely together. The largest spicules are 2·1 mm. long and 0·38 mm. broad, but usually they have the following dimensions—0·97 by 0·154 mm.; 0·89 by 0·15 mm.; 0·84 by 0·126 mm.; 0·7 by 0·12 mm.

Within the cœnenchyma, especially around the principal canals, the spicules have a slender form, and bear only widely separated, delicately pointed, minute spines; they are chiefly straight, but sometimes curved, more rod-like than spindle-shaped. Their dimensions are 0·434 by 0·042 mm.; 0·75 by 0·09 mm.; &c.

The colour of the spicules of the cœnenchyma is throughout a beautiful violet-red. The low calyces are formed of circlets of spicules which spring straight from the stem; the spicules are indistinguishable in form from those of the cœnenchyma, but have a yellow colour, being red only in the older parts of the stem. The collar of the polyps consists of curved spiny spicules. At the base of the tentacles lie curved spicules having one end thickened and covered with the points of sharp spines. They converge in pairs with the points towards the distal end of the tentacle. Their dimensions are 0·336 by 0·028 mm. The spicules of the oral region are white, or, in one case, of a dark purplish red.

Habitat.—Station 177; lat. 16° 45′ S., long. 168° 7′ E., off Api, New Hebrides; 63 to 130 fathoms; volcanic sand.

Siphonogorgia pallida, n. sp. (Pl. II. figs. 2*a*, 2*b*; Pl. V. fig. 5; Pl. VI. fig. 3).

Of this species only two fragments have been obtained; these are, however, sufficiently well marked to form the basis for a new species. The largest piece is a branch giving off at an acute angle near the lower fracture a secondary branch of uniform strength. Numerous remains of twigs show that these arise directly from the main axis, and that they themselves give off short side-twigs. The main branches and twigs have an irregularly bent course. Apparently the whole colony is stiffly-branched and rigid. The main branches are very slightly flattened in one plane, the twigs rising chiefly from two sides. The largest branch is 6 mm. thick at its lower end, and 4 mm. thick where it is broken at its further extremity, a distance of 100 mm. A secondary branch is 5 mm., the twigs 3 mm. in thickness at the base. The polyps are borne only upon the twigs and sub-twigs. They are small, arranged in a spiral, having conical calyces, which, towards the lower portion, are somewhat laterally compressed. The oral region of the polyps is highly retractile. Three or four closely clustered calyces form the apex of the twig, and give to it an apparently thickened end.

In a transverse section of a twig may be seen the four central stem canals, which are

the direct continuation of the cavities of the four terminal polyps, and are separated from one another by thin septa. In the thicker branches these stem canals are wide, and their septa are stiffened with spicules. On their outer side is a thick spicule-bearing cortex. The spicules are very large and easily distinguishable with the naked eye They exhibit, even in the thick branches, longitudinal arrangement. They are thick spindles, usually curved, somewhat blunt at each end, and thickly beset with stout granulated warts. Their dimensions are 2·04 by 0·322 mm.; 1·19 by 0·143 mm.; 2·1 by 0·336 mm.; 2·66 by 0·364 mm.; 1·12 by 0·154 mm.

Within the cœnenchyma the spicules have the form of long rods upon which the warts give place to small spines; between the septa these are further reduced to small blunt knobs. The larger of these internal spicules are 1·19 by 0·098 mm.; 1·148 by 0·056 mm.; 0·742 by 0·026 mm.

Besides these there are small uniform bodies of an irregular club-shaped appearance, somewhat flattened, and covered with sharp projecting spines. They are 0·154 by 0·042 mm.; 0·12 by 0·0042 mm.

The projections of the calyces consist of spindle-shaped, slightly curved or straight, spicules, which, passing out obliquely from the cœnenchyma, surround the calyx; they bear small processes and spines. Their dimensions are 0·49 by 0·07 mm.; 0·42 by 0·056 mm.

The oral region of the polyps may be entirely withdrawn within the calyx, the walls of which are able to close over it. There is also a collar, and spicules, which converge together, occur upon the bases of the tentacles; the latter are thin, rod-like, slightly bent, covered only with weakly-developed spines. The spicules of the collar measure 0·375 by 0·014 mm., those of the tentacles 0·35 by 0·028 mm., 0·224 by 0·028 mm.

The colour of the colony is pale red. The spicules of the cœnenchyma are purple and white irregularly mingled, thus producing the general pale tint. The spicules of the oral region of the polyp are white.

Habitat.—Admiralty Islands.

Order III. GORGONACEA, Verrill.

Section II. HOLAXONIA.

Family MURICEIDÆ, Gray.

Echinogorgia, Kölliker.

Echinogorgia modesta, n. sp. (Pl. IV. fig. 1; Pl. V. fig. 8).

From a flattened base, growing upon foreign bodies, there arise two small simple stems, which are bluntly truncated, thickened but slightly from below upwards. Their

length is 70 mm.; breadth at the base 2 mm. and towards the apex 3 mm. The horny flexible axis is covered over with a thick and rough cœnenchyma, upon which for about a quarter of its length the low polyps are arranged in close spirals.

The calyces are about 0·8 mm. apart, and about 0·8 mm. in diameter and 0·4 mm. in height. They stand at right angles to the cœnenchyma, and have a somewhat elongated oval outline, with the long axis parallel to the length of the stem. The mouth is truncated, with eight lobes. The oral region of the polyp is wholly retractile.

The spicules upon the surface of the cœnenchyma are broad, warty, club-shaped or thick spindle-shaped bodies, often almost flat; those towards the apex are densely covered with rough warts, which are granulated or branched. They measure in length and breadth 0·276 by 0·096 mm.; 0·228 by 0·078 mm.; 0·21 by 0·12 mm.; 0·258 by 0·21 mm.; 0·22 by 0·108 mm.

In the deeper layers the spicules are more spindle-shaped, occasionally thicker at one end than at the other. They bear scattered warts, which project straight outwards, and are terminally expanded or branched. Their dimensions are 0·24 by 0·066 mm.; 0·56 by 0·084 mm.; 0·18 by 0·042 mm. Finally, there are rod-like bodies with elongated, unbranched warts, measuring 0·8 by 0·03 mm.

The colour of the colony is yellowish white.

Habitat.—Stations 233–233A; Bay of Kobé, Japan; 8 to 50 fathoms; mud, sand.

Bebryce, Philippi.

Bebryce, Philippi, Archiv f. Naturgesch., Jahrg. viii. p. 35, 1842.
„ Kölliker, Icones histiolog., part ii. p. 137.

This genus, established in 1842 by Philippi, and characterised particularly by Kölliker, by the arrangement of the spicules, was then known by a single species (*Bebryce mollis*, Phil.) from the Mediterranean. Of this, von Koch has furnished a detailed description.[1] A coral, which was among those collected by the Challenger, exhibits in a most distinct manner the characteristics of this genus.

It was obtained in the Arafura Sea.

Bebryce philippii, n. sp. (Pl. III. figs. 3*a*, 3*b*; Pl. V. fig. 7).

The colony appears as a small stem, branched in one plane, and rising from a flat expanded base. A main axis is distinguishable rising above the manifold lateral growths. Throughout its entire length branches are given off, at first at right angles to the stem,

[1] Gorgonidæ des Golfes von Neapel, p. 54, 1887.

soon, however, becoming more or less parallel with it in their upward course. These give off twigs in a manner identical with the branching of the main axis, but it is only in very rare cases that these twigs again produce side shoots. The branches given off from the middle of the stem are the longest, those above and below showing considerable decrease in length.

The lower branches are in part decayed. The length of the main axis and of the whole colony is 120 mm. Its thickness at the base is 2 mm.; in the upper third it measures 1·5 mm. The length of the branches is 40 to 80 mm., of the twigs 6 to 22 mm.

The cœnenchyma is of a moderate thickness. Its surface appears somewhat rough and granular, when seen in a dried condition under the lens. The polyps are everywhere arranged in spirals, upon the stem, the branches, and upon the twigs. They rise at right angles to the subjacent layer, at intervals of 1 to 1·5 mm., and there are usually four to each spiral. At the apices of the twigs there is always a blunt stolon-like process, from below which arise two elongated polyps, one always situated below the other and on the opposite side. In each polyp there is a rigid calycine region and a retractile oral region, which latter in dead specimens is entirely retracted within the calyx, the mouth being closed without displaying any visible star.

The calyx is cylindrical, terminally truncated, and standing upright upon the stem. It is 1 to 1·5 mm. high, with a diameter of about 1 mm. The terminal calyces stand more obliquely upon the axis, and attain a length of 3 mm.

The spicules of the cœnenchyma and of the calyces form, as in *Bebryce mollis*, two layers; the upper of these shows the characteristic form as described by Kölliker and figured by von Koch (*loc. cit.*, pl. i. fig. 1). I observed, as the essential form, more or less club-shaped or truncated conical structures, the broader part of which is directed outwards and beset with numerous warty protuberances. From the base proceed five or six star-shaped root-like processes bearing simple or branched prolongations. Their height compared with their maximum breadth is as 0·067 to 0·065 mm.; 0·06 to 0·054 mm. Sometimes the horizontal prolongations are united into a plate or scale from which simple or branched processes proceed; this secures a large flat expansion whilst the club itself is shortened and finally is reduced to several slight projections in the centre of the plate. A line of division separating these spicules into halves is clearly distinguishable. Such plates have a diameter of 0·096 to 0·15 mm. In the deeper layer are elongated spicules, which at times incline to the form of the spicules of the cortex. They are elongated club-shaped bodies with jagged spines, or spindle-shaped, straight or curved, with sharply pointed spines. Dimensions 0·72 by 0·01 mm.

The oral portion of the polyp, which is retractile within the calyx, has beneath the base of the tentacles a collar of curved spiny spicules, arranged in a circle. Upon the

bases of the tentacles themselves are three spinose slightly curved spindles, which converge in pairs with their points directed towards the apex of the tentacle, while a third, smaller and flatter, fills the space between the two convergent spindles. The folded-in portion of the tentacles is also equipped with small spicules arranged *en chevron*.

The axis is horny and fibrous, its colour yellowish brown, darker in the older parts, longitudinally grooved, with wide axial canal; the presence of the canal causes the thin twigs, when dried, to appear shrivelled up. As appears from the description, this species resembles very closely the Mediterranean species *Bebryce mollis*. The colony is, however, more branched, the polyp calyces are larger, and there are also differences in the dimensions of the spicules.

The colour of the colony is light brown in the specimens preserved in spirit, white when dried.

Habitat.—Station 190; lat. 8° 56′ S., long. 136° 5′ E., Arafura Sea; 49 fathoms; green mud.

Anthogorgia, Verrill.

Anthogorgia, Verrill, Amer. Jour. Sci., vol. xlv. p. 412, 1868; Proc. Essex Inst., vol. vi. p. 44, Sept. 1869.

The genus was established by Verrill for a species of Muriceidæ from the China Sea, *Anthogorgia divaricata*, Verrill, with the following diagnosis:—"Verrucæ prominent, tubular, the summit eight-rayed in contraction, formed by a thin integument, in the surface of which large, long, mostly bent spindles are embedded at various angles, and so interlaced as to form a sort of network of spicula with depressions between. Cœnenchyma granulous, filled with large warty spicula similar to those of the Verrucæ, but usually shorter and stouter." Specimens taken during the voyage of the "Gazelle," off the coast of West Australia, resemble in habit those of the genus *Villogorgia*, Duch. and Mich., but they do not agree in the character of the spicules, which are never spinose plates, but are spindle-shaped. Moreover, *Anthomuricea*, Wright and Studer, which resembles Verrill's genus in the form of the calyces, differs in the irregular distribution of the calyx spicules. It seems to me best to place in this genus one of the Muriceidæ from Japan, which was obtained among the Challenger specimens.

Anthogorgia japonica, n. sp. (Pl. III. figs. 2*a*, 2*b*; Pl. V. fig. 6).

The colony is upright, branching in one plane, and consists of a main axis, with twigs and secondary twigs from its two sides. The horny axis is covered with a thin

cœnenchyma, upon which the calyces of the polyps are borne at right angles and arranged in spirals.

The main axis rises in a sinuous course, taking an opposite direction at the origin of each branch. It attains a length of 150 mm., with a diameter near the base of 3 mm. and in the upper third of 2 mm. It is not cylindrical, but is flattened at the sides where the branches are given off. These branches, of which the lower ones are as strong as the main axis, arise alternately from the two sides. They arise at an angle of about 45°, but usually curve upwards and take a more vertical course. They attain a length of 120 mm., but decrease towards the apex, so that their apices are on a level with the end of the stem. The larger have a sinuous course like the stem, and are similarly flattened. In a similar manner twigs are given off by the branches; they are very flexible, and here and there bear small secondary twigs. They have a length of 25 to 60 mm., being somewhat thickened terminally.

The cœnenchyma covering the axis is thin, and in a dry condition easily separable. The calyces spring from the stem, branches and twigs, in irregular spirals at intervals of 2 to 2·5 mm. The twigs are terminated by two or three polyps, between which protrudes a blunt stolon. They are cylindrical, terminally truncated, or, at most, slightly thinner in the middle than at either end. The mouth is closed by the folded tentacles, the bases of which form a distinct cover. Their height is 1·8 mm., and the diameter of the upper part 1 mm.

The spicules of the cœnenchyma are in part curved, in part straight spinose spindles, which are arranged in irregular longitudinal lines. They often, however, lie obliquely and transversely to the long axis, and thus cross in manifold fashion. The spines covering them are mostly blunt or abruptly terminated, and loosely distributed. They are continued on the calyces, where they lie partly oblique, partly straight, frequently crossing one another. Their dimensions are 0·93 by 0·078 mm.; 0·84 by 0·096 mm.; 0·63 by 0·06 mm.; 0·73 by 0·07 mm.; 0·78 by 0·084 mm.

The oral region of the polyps bears a collar, composed of curved spicules; it is usually retracted within the calyx margin to the base of the tentacles. The spicules are arranged in threes, two of which converge towards the end of the tentacle, the third lying between them. These spicules form a protective cover to the tentacles, and are found up to the very apex. The oral spicules have the following dimensions:—0·33 by 0·053 mm.; 0·33 by 0·04 mm.; 0·27 by 0·03 mm. In the spindles of the tentacles the spines are fewer and less strongly developed. The axis is yellowish brown, horny, fibrous, and flexible, almost limp in the thinner twigs.

The colour of the colony, in spirit, is brown.

Habitat.—Station 232; lat. 35° 11′ N., long. 139° 28′ E., off Japan; 345 fathoms; green mud.

Family Plexauridæ, Gray.

Eunicea, Lamouroux.

Eunicea, Lamouroux, Hist. des Polyp. flexibl., p. 431, 1816.
„ Milne-Edwards, Hist. Nat. des Coralliaires, t. i. p. 146.

Eunicea palmata, n. sp. (Pl. IV. figs. 2*a*, 2*b*; Pl. V. fig. 9).

Colony upright; slightly branched in one plane, the branches commencing about halfway up the stem. A thick cylindrical stem rises from a broad leaf-like base to a height of 330 mm.; thickness at the base 9 mm., near the apex 6 mm. Its course is irregularly curved. The first branches are given off at a height of 100 mm.; these are few and thick, and arise from both sides at right or obtuse angles. They bend upwards after a short distance, and take a course parallel to that of the stem. The lower ones are large, giving off two or three long twigs with the same characters as the branches. The upper ones are but short, and stand straight out. Branches and twigs are thick, cylindrical; some bend downwards gradually towards the base, thickened terminally. The branches average 190 mm. in length, with a thickness at the base of 7 mm. and of 6 or 7 mm. near the tip. The simple side twigs are 50 to 120 mm. long. The cœnenchyma which covers stem and branches is thick and full of spicules. In a branch 6 mm. in diameter it averages 2 mm. in thickness. The polyps are distributed over the whole surface, and quincuncially arranged; generally they appear at intervals of 2 mm. apart, and only at the ends of the twigs are they more closely disposed, so that the walls of the calyces are in contact. The apex is occupied by a single polyp calyx. Each polyp is formed by a calyx and a completely retractile oral region over which the calyx mouth may be completely closed as a two-lipped slit.

The calyces are low; on the stem and on the lower part of the branches they project but slightly, and are wart-shaped. Towards the ends of the branches and twigs they are higher. Their height is 1 to 2 mm., their diameter 2 to 2·5 mm.

The spicules of the cœnenchyma and of the calyces are mostly club-shaped. Straight and bent clubs with more or less leaf-like ends may be distinguished; they are covered with rough warts, or with branched, curved, and straight processes. Dimensions 0·38 by 0·1 mm.; 0·5 by 0·12 mm.; 0·4 by 0·09 mm. In addition, there occur straight and bent spindles with warts and spines, or with irregular processes which may be branched; these exhibit manifold transitions towards the club-shaped form. Dimensions 0·35 by 0·05 mm.; 0·5 by 0·05 mm.; 0·43 by 0·07 mm.; 0·33 by 0·05 mm.

Branched spindle-shaped bodies also occur: flat spindles forked at one or both ends, or giving off processes from the middle. Some of them may be regarded as twin forms. The clubs always form the superficial layer. Irregularly distributed in the cœnenchyma, they are arranged in the calyces in palisade fashion, parallel to the vertical axis. The oral region is furnished with only a few small glassy spindles, which are embedded in the tentacles.

The axis is horny and flexible; it contains a very wide axial canal and a thick cortex of lamellar structure. In cross-section a vesicular appearance is produced by the partial separation of the lamellæ. The colour of the axis is brown, the cœnenchyma a lighter shade, the calyces darker.

Habitat.—Station 308; lat. 50° 8′ 30″ S., long. 74° 41′ 0″ W., off Tom Bay, Magellan Strait; 175 fathoms; blue mud.

GEOGRAPHICAL DISTRIBUTION.

List of the ALCYONARIA (Pennatulacea excepted) obtained during the Voyage of the Challenger, arranged in the order of the Stations at which they occurred, with information as to the depth and nature of the sea bottom.

STATION IV.—January 16, 1873; lat. 36° 25′ N., long. 8° 12′ W., off Cadiz; depth, 600 fathoms; bottom, blue mud.

Strophogorgia challengeri, n. sp.

STATION 3.—February 18, 1873; lat. 25° 45′ N., long. 20° 14′ W., south-west of the Canary Islands; depth, 1525 fathoms; bottom, hard ground.

Acanella arbuscula, Johns. | *Anthomastus canariensis*, n. sp.

Pleurocorallium johnsoni, Gray.

STATION 23.—March 15, 1873; lat. 18° 24′ N., long. 63° 28′ W., off Sombrero Island; depth, 450 fathoms; bottom, Pteropod ooze.

Acanella eburnea, Pourtal. | *Juncella barbadensis*, D. and M.
Primnoella distans, Studer. | *Clavularia tubaria*, n. sp.

STATION 56.—May 29, 1873; lat. 32° 8′ 45″ N., long. 64° 59′ 35″ W., off Bermuda; depth, 1075 fathoms; bottom, coral mud.

Acanella simplex, Verrill. | *Sympodium armatum*, n. sp.

Off Bermuda; shallow water.

Plexaura valenciennesi, n. sp. | *Pseudoplexaura crassa* (Ell. and Sol.).

Gorgonia flabellum, L.

STATION 70.—June 26, 1873; lat. 38° 25′ N., long. 35° 50′ W., west of the Azores; depth, 1675 fathoms; bottom, Globigerina ooze.

Strophogorgia fragilis, n. sp.

Station 71.—June 27, 1873; lat. 38° 18′ N., long. 34° 48′ W., west of the Azores; depth, 1675 fathoms; bottom, Globigerina ooze.

Telesto rigida, n. sp.

Station 75.—July 2, 1873; lat. 38° 38′ 0″ N., long. 28° 28′ 30″ W., off the Azores; depth, 450 fathoms; bottom, volcanic mud.

Bellonella bocagei, S. Kent.

Station 78.—July 10, 1873; lat. 37° 26′ N., long. 25° 13′ W., off the Azores; depth, 1000 fathoms; bottom, volcanic mud.

Clavularia elongata, n. sp.

Station 85.—July 19, 1873; lat. 28° 42′ N., long. 18° 6′ W., off Palma, Canary Islands; depth, 1125 fathoms; bottom, volcanic mud.

Ceratoisis palmæ, n. sp. | *Pleurocorallium johnsoni*, Gray.

Off St. Paul's Rocks, Mid Atlantic; depth, 80 fathoms.

Paramuricea æquatorialis, n. sp. | *Placogorgia atlantica*, n. sp.

Station 122.—September 10, 1873; lat. 9° 5′ S., long. 34° 50′ W., off Pernambuco, Brazil; depth, 350 fathoms; bottom, red mud.

Dasygorgia spiculosa, Verrill. | *Primnoella distans*, Studer (Stations 122A–C).

Off Bahia, Brazil; depth, 7 to 20 fathoms.

Muricea bicolor, n. sp. | *Leptogorgia purpurea* (Pallas).

Telesto (*Carijoa*) *rupicola*, F. Müller.

Off Nightingale Island, Tristan da Cunha; depth, 100 to 150 fathoms.

Clavularia cylindrica, n. sp. | *Sympodium glomeratum*, n. sp.

Amphilaphis regularis, n. sp.

Stations 135A–C.—October 16, 17, 1873; off Tristan da Cunha; depth, 100 to 550 fathoms; bottom, hard ground, shells, gravel.

Amphilaphis regularis, n. sp. (75 fathoms).
Clematissa verrilli, n. sp.
Sarakka crassa, Danielssen.
Sarcophytum atlanticum, n. sp. (60 fathoms).

Simon's Bay, Cape of Good Hope; shallow water.

Eunicella papillosa, Esper. | (?) *Lophogorgia flammea* (Ell. and Sol.).

STATION 145A.—December 27, 1873; lat. 46° 41′ S., long. 38° 10′ E., off Marion Island; depth, 310 fathoms; bottom, volcanic sand.

Primnoisis sparsa, n. sp. (85 fathoms).
Primnoisis antarctica (Studer).
Primnoides sertularoides, n. sp.
Acanthogorgia ramosissima, n. sp.
Stenella spinosa, n. sp.
Thouarella variabilis, n. sp., vars. *a* and *b*.
Lophogorgia lütkeni, n. sp.
Pleurocorallium secundum, Dana.

Kerguelen; depth, 10 to 80 fathoms.

Primnoisis ambigua, n. sp.

STATION 148A.—January 3, 1874; lat. 46° 53′ S., long. 51° 52′ E., off the Crozet Islands; depth, 550 fathoms; bottom, hard ground, gravel, shells.

Thouarella antarctica (Val.).

STATION 150.—February 2, 1874; lat. 52° 4′ S., long. 71° 22′ E., between Kerguelen and Heard Islands; depth, 150 fathoms; bottom, coarse gravel.

Thouarella variabilis, n. sp., var. *gracilis*, nov.

STATION 151.—February 7, 1874; lat. 52° 59′ 30″ S., long. 73° 33′ 30″ E., off Heard Island; depth, 75 fathoms; bottom, volcanic mud.

Alcyonium antarcticum, n. sp.

STATION 153.—February 14, 1874; lat. 65° 42′ S., long. 79° 49′ E., Antarctic Ocean; depth, 1675 fathoms; bottom, blue mud.

Callozostron mirabilis, n. sp.

STATION 162.—April 2, 1874; lat. 39° 10′ 30″ S., long. 146° 37′ 0″ E., off East Moncœur Island; depth, 38 fathoms; bottom, sand and shells.

Mopsea encrinula (Lamk.). | *Melitodes rugosa*, n. sp.

STATION 163A.—April 4, 1874; lat. 36° 59′ S., long. 150° 20′ E., off Twofold Bay; depth, 150 fathoms; bottom, green mud.

Primnoella grandisquamis, n. sp. | *Primnoella australasiæ*, Gray.
Eunephthya fusca, n. sp.

Station 163b.—June 3, 1874; lat. 33° 51′ 15″ S., long. 151° 22′ 15″ E., off Port Jackson, Sydney; depth, 35 fathoms; bottom, hard ground.

Acanthoisis flabellum, n. sp. | *Primnoella australasiæ*, Gray.
Mopsea dichotoma (L.). | *Suberia genthi*, n. sp.
Parisis australis, n. sp.

Station 170.—July 14, 1874; lat. 29° 55′ S., long. 178° 14′ W., off the Kermadec Islands; depth, 520 fathoms; bottom, volcanic mud.

Dasygorgia expansa, n. sp.

Station 171.—July 15, 1874; lat. 28° 33′ S., long. 177° 50′ W., north of the Kermadec Islands; depth, 600 fathoms; bottom, hard ground.

Dasygorgia acanthella, n. sp. | *Calyptrophora wyvillei*, n. sp.
Dasygorgia axillaris, n. sp. | *Stachyodes regularis*, n. sp.
Thouarella moseleyi, n. sp.

Station 172.—July 22, 1874; lat. 20° 58′ S., long. 175° 9′ W., off Tongatabu; depth, 18 fathoms; bottom, coral mud.

Sarcophytum tongatabuensis, n. sp.

Station 174b.—August 3, 1874; lat. 19° 6′ 45″ S., long. 178° 17′ 0″ E., off Kandavu; depth, 255 fathoms; bottom, coral mud.

Ceratoisis grandiflora, Studer.

Station 174c.—August 3, 1874; lat. 19° 7′ 50″ S., long. 178° 19′ 35″ E., off Kandavu; depth, 610 fathoms; bottom, coral mud.

Calyptrophora japonica, Gray. | *Ceratoisis grandiflora*, Studer.
Stenella gigantea, n. sp.

Station 174d.—August 3, 1874; lat. 19° 5′ 50″ S., long. 178° 16′ 20″ E., off Kandavu; depth, 210 fathoms; bottom, coral mud.

Ceratoisis grandiflora, Studer.

Off Kandavu; Reefs.

Ceratoisis nuda, n. sp. | *Acamptogorgia alternans*, n. sp.
Sarcophytum glaucum, Q. and G.

Fiji Reefs.

Calypterinus allmani, n. sp. (probably from deep water).

Sarcophytum trocheliophorum, Marenzeller, var. *amboinense*.

STATION 177.—August 18, 1874; lat. 16° 45′ S., long. 168° 7′ E., off Api, New Hebrides; depth, 63 to 130 fathoms; bottom, volcanic sand.

Scirpearella profunda, n. sp.
Scirpearella gracilis, n. sp.
Melitodes nodosa, n. sp.
Villogorgia intricata, Gray.
Siphonogorgia pustulosa, n. sp.

Torres Strait; depth, 3 to 11 fathoms.

Echinogorgia pseudosassapo, Kölliker.
Leptogorgia torresia, n. sp.
Juncella juncea, Pallas, var. *alba*, nov.
Ellisella maculata, Studer.
Iciligorgia orientalis, Ridley.
Melitodes dichotoma, Pallas.
Melitodes esperi, n. sp.
Spongodes macrospina, n. sp.
Spongodes umbellata, n. sp.
Spongodes bicolor, n. sp.
Spongodes heterocyathus, n. sp.
Spongodes coronata, n. sp.
Telesto (*Carijoa*) *trichostemma* (Dana).

STATION 186.—September 8, 1874; lat. 10° 30′ S., long. 142° 18′ E., off Cape York; depth, 8 fathoms; bottom, coral mud.

Plexauroides prælonga, n. sp.
Juncella gemmacea (Val.).
Spongodes spinosa, Gray.
Heliopora cærulea, Blainville (? on Reef).

STATION 188.—September 10, 1874; lat. 9° 59′ S., long. 139° 42′ E., Arafura Sea; depth, 28 fathoms; bottom, green mud.

Elasmogorgia filiformis, n. sp.
Spongodes corymbosa, n. sp.
Spongodes monticulosa, n. sp.

STATION 190.—September 12, 1874; lat. 8° 56′ S., long. 136° 5′ E., Arafura Sea; depth, 49 fathoms; bottom, green mud.

Bebryce philippii, n. sp.
Muricella umbraticoides, Studer.
Muricella crassa, n. sp.
Melitodes rubeola, n. sp. and var.
Telesto (*Carijoa*) *arborea*, n. sp.

Station 192.—September 26, 1874; lat. 5° 49′ 15″ S., long. 132° 14′ 15″ E., off Ki Islands; depth, 140 fathoms; bottom, blue mud.

Dasygorgia cupressa, n. sp.
Thouarella hilgendorfi (Studer).
Caligorgia sertosa, n. sp.
Muricella tenera, Ridley.
Spongodes collaris, n. sp.
Spongodes laxa, n. sp.
Spongodes rhodosticta, n. sp.
Parisis fruticosa, Verrill.
Pleurocorallium secundum, Dana.

Station 194.—September 29, 1874; lat. 4° 34′ 0″ S., long. 129° 57′ 30″ E., off Banda Island; depth, 200 fathoms; bottom, volcanic mud.

Acanella rigida, n. sp.
Pleurocorallium secundum, Dana.

Station 194a.—September 29, 1874; lat. 4° 31′ 0″ S., long. 129° 57′ 20″ E., off Banda Island; depth, 360 fathoms; bottom, volcanic mud.

Acanella rigida, n. sp.

Banda; depth, 14 fathoms.

Platycaulos danielsseni, n. sp.
Ellisella maculata, Studer.
Sarcophytum ambiguum, n. sp.

Amboina; depth, 15 to 25 fathoms.

Melitodes lævis, n. sp.
Melitodes fragilis, n. sp.
Siphonogorgia köllikeri, n. sp.
Siphonogorgia pendula, n. sp.
Xenia elongata, Dana.
Scirpearella moniliforme, n. sp. (100 fathoms).

Station 201.—October 26, 1874; lat. 7° 3′ N., long. 121° 48′ E., off Samboangan, Philippine Islands; depth, 82 fathoms; bottom, stones, gravel.

Dasygorgia geniculata, n. sp.
Dasygorgia axillaris, n. sp.
Ceratoisis philippinensis, n. sp.
Echinogorgia ramulosa (Gray).

Samboangan, Philippine Islands; depth, 10 fathoms.

Melitodes philippinensis, n. sp. (Reefs).
Melitodes sinuata, n. sp. (Reefs).
Paranephthya capitulifera, n. sp.
Tubipora musica, Linneus.
Heliopora cærulea, Blainville.

STATION 203.—October 31, 1874; lat. 11° 6′ N., long. 123° 9′ E.; off Panay, Philippines; depth, 20 fathoms; bottom, mud.

Echinomuricea indomalaccensis, Ridley.

Spongodes dendrophyta, n. sp.

STATION 207.—January 16, 1875; lat. 12° 21′ N., long. 122° 15′ E., off Tablas Island, Philippines; depth, 700 fathoms; bottom, blue mud.

Acanthogorgia longiflora, n. sp.

STATION 208.—January 17, 1875; lat. 11° 37′ N., long. 123° 31′ E., Philippines; depth, 18 fathoms; bottom, blue mud.

Plexaurella philippinensis, n. sp.

Scleronephthya pustulosa, n. sp.

Sarcophytum philippinensis, n. sp.

Zebu Reefs, Philippines.

Spongodes digitata, n. sp.

Spongodes spicata, n. sp.

STATION 210.—January 25, 1875; lat. 9° 26′ N., long. 123° 45′ E., Philippines; depth, 375 fathoms; bottom, blue mud.

Muriceides fragilis, n. sp.

STATION 212.—January 30, 1875; lat. 6° 54′ N., long. 122° 18′ E., off Samboangan, Philippines; depth, 10 fathoms; bottom, sand.

Spongodes anguina, n. sp.

Spongodes florida (Esper).

Spongodes bicolor, n. sp.

STATION 214.—February 10, 1875; lat. 4° 33′ N., long. 127° 6′ E., south of the Philippines; depth, 500 fathoms; bottom, blue mud.

Dasygorgia squarrosa, n. sp.

Admiralty Islands; depth, 16 to 25 fathoms.

Muricella gracilis, n. sp.

Suberogorgia suberosa (Pallas).

Spongodes nephthyæformis, n. sp.

Siphonogorgia pallida, n. sp.

Station 232.—May 12, 1875; lat. 35° 11′ N., long. 139° 28′ E., *Hyalonema* ground, off Japan; depth, 345 fathoms; bottom, green mud.

Strophogorgia petersi, n. sp.
Dasygorgia geniculata, n. sp.
Ceratoisis paucispinosa, n. sp.
Caligorgia flabellum (Ehrenberg).
Anthogorgia japonica, n. sp.
Acamptogorgia arbuscula (Gray).
Acis pustulata, n. sp.
Muricella complanata, n. sp.
Muricella perramosa, Ridley.
Muricella nitida, Verrill (?).
Scirpearella rubra, n. sp.
Juncella racemosa, n. sp.
Gorgonella orientalis, n. sp.
Suberogorgia verriculata (Esper).
Suberogorgia köllikeri, n. sp.
Keroeides koreni, n. sp.
Melitodes nodosa, n. sp.
Parisis minor, n. sp.
Chironephthya dipsacea, n. sp.
Chironephthya scoparia, n. sp.
Chironephthya crassa, n. sp.
Siphonogorgia godeffroyi, Kölliker.

Stations 233–233a.—May 17–19, 1875; lat. 34° 39′–34° 38′ N., long. 135° 14′–135° 1′ E., Bay of Kobé, Japan; depth, 8 to 50 fathoms; bottom, mud, sand.

Echinogorgia modesta, n. sp.
Euplexaura pinnata, n. sp.
Euplexaura parciclados, n. sp.

Station 235.—June 4, 1875; lat. 34° 7′ N., long. 138° 0′ E., south of Japan; depth, 565 fathoms; bottom, green mud.

Strophogorgia verrilli, n. sp.
Anthomastus steenstrupi, n. sp.

Station 237.—June 17, 1875; lat. 34° 37′ N., long. 140° 32′ E., off Japan; depth, 1875 fathoms; bottom, blue mud.

Dasygorgia japonica, n. sp.
Stenella dæderleini, n. sp.
Strophogorgia verrilli, n. sp.

Station 241.—June 23, 1875; lat. 35° 41′ S., long. 157° 42′ E., North Pacific, east of Japan; depth, 2300 fathoms; bottom, red clay.

Bathygorgia profunda, n. sp.

Tahiti; depth 30 to 70 fathoms.

Spongodes carnea, n. sp.
Spongodes pustulosa, n. sp.
Spongodes cervicornis, n. sp.

STATION 307.—January 4, 1876; lat. 49° 24′ 30″ S., long. 74° 23′ 30″ W., off Port Grappler, Magellan Strait; depth, 140 fathoms; bottom, blue mud.

Dasygorgia flexilis, n. sp.
Acanella chiliensis, n. sp.
Plumarella delicatissima, n. sp.
Acanthogorgia ridleyi, n. sp.
Anthomuricea argentea, n. sp.

STATION 308.—January 5, 1876; lat. 50° 8′ 30″ S., long. 74° 41′ 0″ W., off Tom Bay, Magellan Strait; depth, 175 fathoms; bottom, blue mud.

Thouarella köllikeri, n. sp.
Primnoella flagellum, Studer.
Primnoella biserialis, n. sp.
Acanthogorgia laxa, n. sp.
Paramuricea ramosa, n. sp.
Eunicea palmata, n. sp.
Leptogorgia arbuscula (Philippi).
Alcyonium haddoni, n. sp.

STATION 310.—January 10, 1876; lat. 51° 27′ 30″ S., long. 74° 3′ 0″ W.; Sarmiento Channel; depth, 400 fathoms; bottom, blue mud.

Thouarella köllikeri, n. sp.
Clematissa robusta, n. sp.
Paramuricea laxa, n. sp.
Leptogorgia purpurea (Pallas).

STATION 311.—January 11, 1876; lat. 52° 45′ 30″ S., long. 73° 46′ 0″ W., off Port Churruca; depth, 245 fathoms; bottom, blue mud.

Clematissa obtusa, n. sp.

STATION 313.—January 20, 1876; lat. 52° 20′ S., long. 67° 39′ W., Atlantic entrance to Magellan Strait; depth, 55 fathoms; bottom, sand.

Alcyonium sollasi, n. sp.

STATION 320.—February 14, 1876; lat. 37° 17′ S., long. 53° 52′ W., off Monte Video; depth, 600 fathoms; bottom, green sand.

Primnoisis rigida, n. sp.
Stenella acanthina, n. sp.
Primnoella magellanica, Studer.
Primnoella murrayi, n. sp.
Sympodium verrilli, n. sp.

STATION 343.—March 27, 1876; lat. 8° 3′ S., long. 14° 27′ W., off Ascension; depth, 425 fathoms; bottom, volcanic sand.

Dasygorgia melanotrichos, n. sp.

STATION 344.—April 3, 1876; lat. 7° 54′ 20″ S., long. 14° 28′ 20″ W., off Ascension; depth, 420 fathoms; bottom, volcanic sand.

Stenella johnsoni, n. sp.
Callistephanus koreni, n. sp.

BATHYMETRICAL RANGE.

During the cruise of the Challenger, 196 species of Alcyonaria (excluding Pennatulacea) were obtained. These may be grouped according to the depths from which they were collected as follows :—

Zone.	Fathoms.	Species.
I.	0 to 100	90
II.	100 to 400	64
III.	400 to 1000	26
IV.	1000 to 2000	15
V.	2000 to 3000	1

From the above we see that the number of species lessens gradually from the surface waters to the greater depths.

The proportion between the number of species found in the first zone to the number in subsequent zones would appear much increased, were we to include with the foregoing species those previously recognised, which for the most part belong to this first zone.

The character of the fauna in the first zone varies in the different seas and latitudes examined, and more especially in the surface waters which are most exposed to climatic influences.

It is possible to distinguish a yet more littoral fauna, which extends to the level of the low tide mark, from one extending into the deeper water. In the temperate and cold seas there are only a few species in this littoral fauna, where inconspicuous forms of Cornularidæ, *e.g.*, *Cornularia*, *Clavularia*, *Sarcodictyon*, grow on the rocks or cover the surfaces of *Zostera* or of Algæ. The only addition to these is a low growing *Alcyonium*, or, as upon the east coast of America, a bushy *Telesto*.

In the equatorial seas this zone is somewhat richer. In the West Indies and Brazil the occurrence of the following has been ascertained :—Some Xenidæ; among the Alcyonidæ, *Ammothea;* among the Gorgonaceæ, Scleraxonia, such as *Briareum*, and among the Holaxonia, *Plexaurella*, *Hymenogorgia*, *Gorgonia*, *Leptogorgia*.

Similarly on the west coast of America, species of *Leptogorgia*, which are there very plentiful, grow within these limits, associated with *Muricea* and *Eumuricea*.

Among the Coral Reefs of the Pacific and Indian Oceans a large number of species is to be found growing within this littoral zone to a depth of 10 fathoms. By far the greater number of these belong to the genera :—*Sympodium* (Cornularidæ) ; *Tubipora* (Tubiporidæ) ; *Xenia* (Xenidæ) ; *Lobularia*, *Lobophytum*, and *Sarcophytum*, among the Alcyonidæ ; *Nephthya*, *Ammothea*, *Spongodes*, among the Nepthyidæ ; and *Heliopora* among the Helioporidæ.

In the deeper water, down to 100 fathoms, there predominate in the northern seas :—*Clavularia* and *Sympodium* (Cornularidæ) ; *Anthomastus*, *Alcyonium* (Alcyonidæ) ; *Gersemia*, *Eunephthya*, *Duva* (Nephthyidæ) ; *Anthothela*, *Paragorgia* (Scleraxonia) ; *Paramuricea*, *Danielssenia*, and *Primnoa* (Holaxonia), the last at depths below 50 fathoms.

On the eastern shores of the North Atlantic and in the Mediterranean, the following genera are particularly frequent :—*Alcyonium*, *Bellonella*, *Corallium*, *Paramuricea*, *Bebryce*, *Eunicella* (the last on the whole east coast of the Atlantic, as far as the Cape of Good Hope), *Leptogorgia*, *Gorgonia*. Here also, below 50 fathoms, are found Primnoidæ, like *Primnoa* and *Caligorgia*, with *Isidella* among the Isidæ.

On the west coast the predominant forms are *Anthothela*, *Titanideum*, *Leptogorgia*, and *Gorgonia*.

The east coast of the Atlantic equatorial region is not rich in species, while such as occur resemble those of the temperate seas, a fact which is to be explained by the relatively low temperature of the water off the west coast of Africa. The species so far known belong to the following genera :—*Scleranthelia*, *Bellonella*, *Paramuricea*, *Eunicella*, *Gorgonia*, *Leptogorgia*, *Juncella*, *Verrucella*.

To the west, on the coasts of Brazil and the West Indies, there are many genera well represented by numerous species :—*Anthelia*, *Telesto*, *Acanthogorgia*, *Hypnogorgia*, *Villogorgia*, *Muricea*, *Acis*, *Thesea*, *Eunicea*, *Plexaura*, *Plexaurella*, *Pseudoplexaura*, *Gorgonia*, *Leptogorgia*, *Phyllogorgia*, *Verrucella*, *Juncella*. There are also, in the deeper water below 50 fathoms, *Caligorgia*, *Paramuricea*, *Placogorgia*.

In the south temperate region of the Atlantic, about the Cape of Good Hope, representatives occur of the genera :—*Anthelia*, *Eunephthya*, *Spongioderma*, *Eunicella*, *Platygorgia*, *Lophogorgia*, *Gorgonella*, *Euplexaura*, *Isidella*.

In the temperate regions of the west coast are found *Suberia* and, in the deeper water below 50 fathoms, *Primnoella*.

In the Pacific Ocean this zone is characterised along the whole west coast of America by the predominance of the Muriceidæ and Gorgonidæ, which there exhibit the maximum number of species. Thus the genera *Muricea* and *Eumuricea*, together, include fifteen species ; *Heterogorgia* is represented by three species, *Psammogorgia* by four species,

Eugorgia by seven, *Leptogorgia* by twenty, and *Callipodium* by two species. *Eugorgia* and *Heterogorgia* are found in this region only.

Off the Peruvian coast a single species of the Indo-Pacific genus *Echinogorgia* occurs.

While upon the eastern borders of the Pacific, there is thus a fauna much the same in its character along the whole extent of the coast line of America, the fauna of the opposite shores of the Pacific is partly temperate, partly tropical in character. Far down along the eastern shores of Asia, Arctic species are to be met with; the fauna of Japan is of a mixed nature. Most of the species found towards the north belong to the genera :—*Spongodes* (mostly small forms), *Nephthya*, *Mopsella*, *Acabaria*, *Paramuricea*, *Euplexaura*, *Ellisella*.

In the tropical regions of the Pacific there is an unusually rich fauna, which extends with a very uniform character to the tropical regions of the Indian Ocean. Particularly where the coast is sandy or gravelly, at depths of 10 to 60 fathoms, Alcyonaria abound, associated with Sponges, forming vast forests, where every fresh search brings new forms to light. Here in the greatest abundance are :—Nephthyidæ (among which the subfamily Siphonogorginæ is confined to this region); Scleraxonia, particularly the Melitodidæ; among the Holaxonia certain genera of Muriceidæ, Plexauridæ, and more especially the Gorgonellidæ.

The following genera are well represented in this zone of the Indo-Pacific region :—*Telesto* (*Carijoa*), *Cœlogorgia*, *Tubipora*, *Xenia*, *Lobularia*, *Sarcophytum*, *Lobophytum*, *Ammothea*, *Nephthya*, *Spongodes*, *Paranephthya*, *Siphonogorgia*, *Solenocaulon*, *Iciligorgia*, *Suberogorgia*, *Melitodes*, *Mopsella*, *Acabaria*, *Psilacabaria*, *Wrightella*, *Clathraria*, *Parisis*, *Pleurocorallium*, *Mopsea*, *Isis*, *Villogorgia*, *Anthogorgia*, *Menella*, *Echinomuricea*, *Echinogorgia* (a great many species), *Astrogorgia*, *Muricella* (many species), *Plexauroides*, *Plexaurella*, *Platycaulos*, *Leptogorgia* (many species), *Gorgonia* (but few species), *Nicella*, *Juncella*, *Ellisella*, *Verrucella*, *Gorgonella*, *Ctenocella*, *Phenilia*.

In the south temperate region of the Pacific there is relatively a paucity of species, there being only a few forms at present known from the shallower depths about the coast of Tasmania, from Bass Strait and Antarctic Islands; such are :—*Alcyonium*, *Suberia*, *Mopsella*, *Primnoisis* (from Kerguelen), *Primnoella*, and *Thouarella*.

In the whole zone from 0 to 100 fathoms, there are found in the deeper parts between 60 and 100 fathoms, isolated species belonging typically to deeper water, *e.g.*, certain forms of *Dasygorgia*, *Ceratoisis*, *Primnoisis*, and Primnoidæ. Especially in the south temperate regions, as may be inferred from what has been said, Primnoidæ and Primnoidinæ extend into the shallower water; thus, in Magellan Strait, *Primnoella magellanica* is to be met with in depths up to 42 fathoms; off the coast of South Australia, *Primnoella australasiæ* extends to 30 fathoms; *Thouarella antarctica*, in the Falkland Islands, occurs up to 45 fathoms; near Kerguelen, *Primnoisis ambigua* is found

between 10 and 80 fathoms; whilst *Dasygorgia geniculata*, *Dasygorgia axillaris*, and *Ceratoisis philippinensis*, from the Philippines, are found in 82 fathoms.

The fauna of the second zone, 100 to 400 fathoms, which yielded a total of sixty-four species, is of a more uniform character, at least as regards the genera, than was to be recognised in the previous zone. At the same time it happens that individual stations have a local character of their own, due to species and genera which extend to these deeper zones from those above. Thus, here and there, below 100 fathoms, there are representatives of *Alcyonium*, certain species of *Spongodes*, *Parisis*, *Suberogorgia*, *Anthogorgia*, *Muricella*, *Eunicella*, *Eunicea*, *Lophogorgia*, *Leptogorgia*, *Juncella*. But especially prominent are Dasygorgidæ, Isidæ, and Primnoidæ. The following are chiefly represented:—*Strophogorgia*, *Dasygorgia*, *Chrysogorgia*, *Ceratoisis*, *Acanella*, *Primnoisis* (the last particularly in the Antarctic Ocean), *Primnoa*, *Stenella*, *Thouarella*, *Amphilaphis*, *Plumarella*, *Caligorgia*, *Primnoides*, *Paramuricea*, *Anthomuricea* (the two last in the Atlantic), *Clematissa* (South Atlantic), *Acanthogorgia*, *Muriceides*, *Stenogorgia*, *Scirpearella*, *Scirpearia* (Atlantic), *Keroeides* (Japan), *Chironephthya* (Japan), *Eunephthya*, *Anthomastus*, *Bellonella*, *Sarakka*, *Clavularia*, *Sympodium*, *Scleranthelia*, *Telesto* (s. str.).

In the Arctic Ocean there are Alcyonidæ and Nepthyidæ which frequent this zone, as:—*Væringia*, *Duva*, *Drifa*, *Nannodendron*, *Fulla*, *Eunephthya*, *Gersemia*, *Sarakka*, *Bellonella*, *Crystallophanes*, besides *Organidus*, *Clavularia*, *Sympodium*, *Paragorgia*, *Anthomastus*, and *Primnoa*.

In the third zone, at depths of 400 to 1000 fathoms, except for a few delicate forms of Cornularidæ and Alcyonidæ, the Dasygorgidæ and Primnoidæ reign almost alone. Near to Ascension was obtained a distinct Gorgonid, which is the only deep-sea representative of this family at present known. The genera that have been observed are:—*Sympodium*, *Bellonella*, *Anthomastus*, *Væringia*, *Duva*, *Barathrobius*, *Sarakka*, *Strophogorgia*, *Dasygorgia* (here the chief representatives of the group), *Chrysogorgia*, *Iridogorgia*, *Ceratoisis*, *Acanella*, *Primnoisis*, *Calyptrophora*, *Stachyodes*, *Stenella*, *Thouarella*, *Primnoella*, *Acanthogorgia* (one species), *Callistephanus*.

Only fifteen species were found in the fourth zone, at depths of 1000 to 2000 fathoms. Except for a few Cornularidæ and Alcyonidæ, which were met with in the previous zone, they are Holaxonia, viz., Dasygorgidæ, Primnoidæ, and Gorgonellidæ, and one Scleraxonid, *Pleurocorallium*. The colonies are mostly unbranched, the polyps arranged in a single row. They probably form creeping stems, which extend, in a stolon-like fashion, along the Globigerina ooze, and upon which the polyps are arranged so as to receive the food sinking down from above. Most striking, in this connection, is a Primnoid, *Callozostron mirabilis*, which was found in 1675 fathoms, in latitude 65° S. The stolon-like creeping stem is covered with polyps, except in one plane, upon which probably the stem had lain, while the apertures of the polyps are all directed towards the opposite side.

The following genera have, up to the present time, been observed in this deeper zone :—*Sympodium*, *Clavularia*, *Anthomastus*, *Barathrobius*, *Pleurocorallium*, *Strophogorgia*, *Ceratoisis*, *Acanella*, *Dasygorgia*, *Callozostron*, *Stenella*, *Scirpearella*.

In the fifth zone, between 2000 and 3000 fathoms, at a depth of 2300 fathoms, there was obtained but a single distinct species belonging to the Isidæ,—*Bathygorgia profunda*. This species shows the above-mentioned character of the deep-sea Alcyonaria to the fullest extent. A simple, probably creeping, stem bears the polyps in a single row; these stand erect, and have their walls strengthened by the rigid spicules.

PLATE I.

PLATE I.

Fig. 1. *Siphonogorgia pendula*, n. sp.

Fig. 1*a*. Colony; nat. size.
Fig. 2*b*. Polyps; enlarged.

Fig. 2. *Siphonogorgia köllikeri*, Wright and Studer.

Colony; nat. size.

R. Armbruster Bern, del. lith. et imp.

SIPHONOGORGIA.

PLATE II.

PLATE II.

Fig. 1. *Siphonogorgia pustulosa*, n. sp.

Fig. 1*a*. Colony; nat. size.
Fig. 1*b*. Portion of twig with polyps; enlarged.

Fig. 2. *Siphonogorgia pallida*, n. sp.

Fig. 2*a*. Colony; nat. size.
Fig. 2*b*. Portion of twig with polyps; enlarged.

R. Armbruster Bern. del. lith. et imp.

SIPHONOGORGIA.

PLATE III.

PLATE III.

Fig. 1. *Telesto* (*Carijoa*) *trichostemma* (Dana).

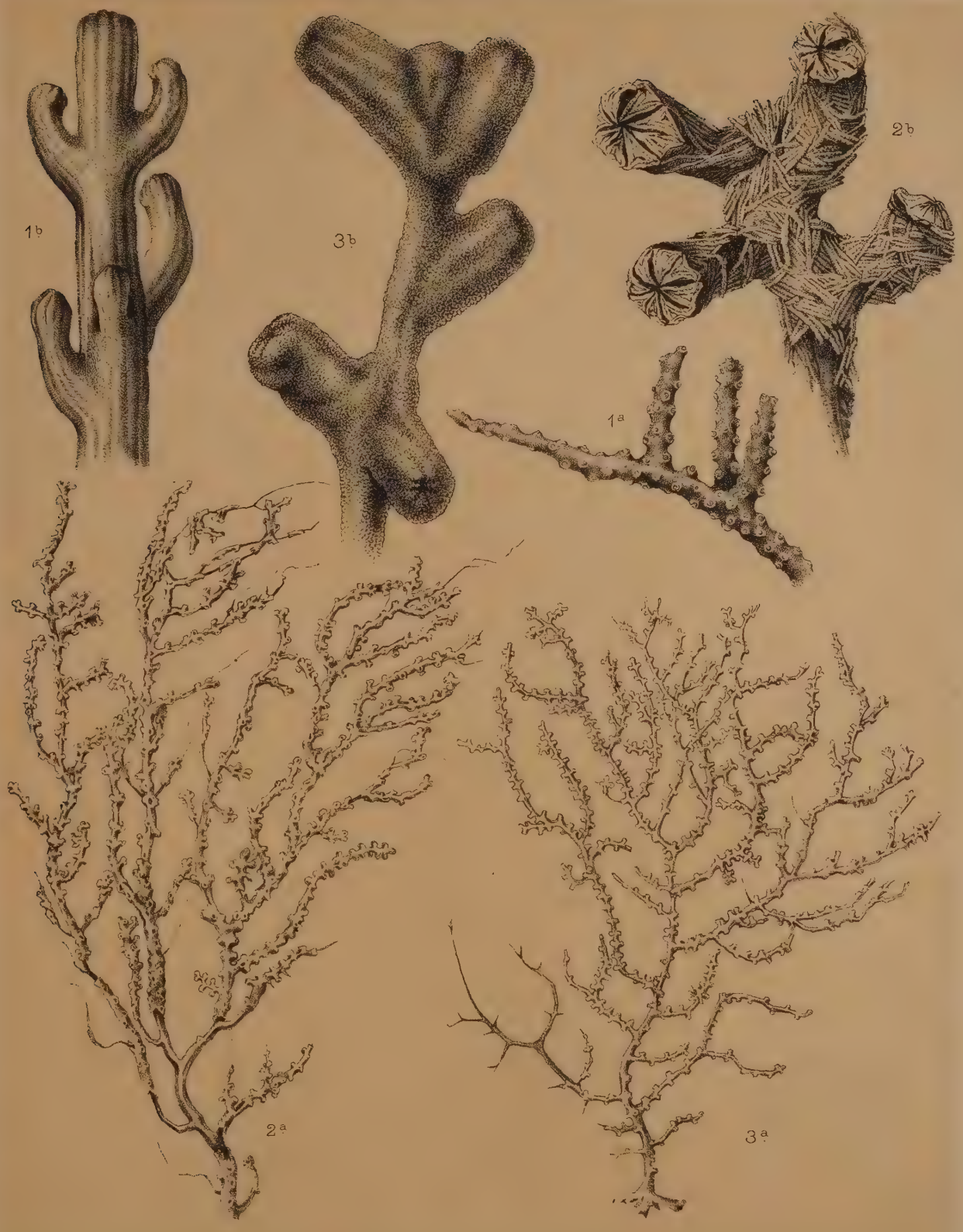
Fig. 1*a*. Small colony invested by the parasitic sponge.
Fig. 1*b*. Apex of twig with axial and lateral polyps; enlarged.

Fig. 2. *Anthogorgia japonica*, n. sp.

Fig. 2*a*. Colony; nat. size.
Fig. 2*b*. Portion of twig with polyps; enlarged.

Fig. 3. *Bebryce philippii*, n. sp.

Fig. 3*a*. Colony; nat. size.
Fig. 3*b*. Apex of twig with polyps; enlarged.



R. Armbruster Bern. del. lith. et imp

CARIJOA. ANTHOGORGIA. BEBRYCE.

PLATE IV.

PLATE IV.

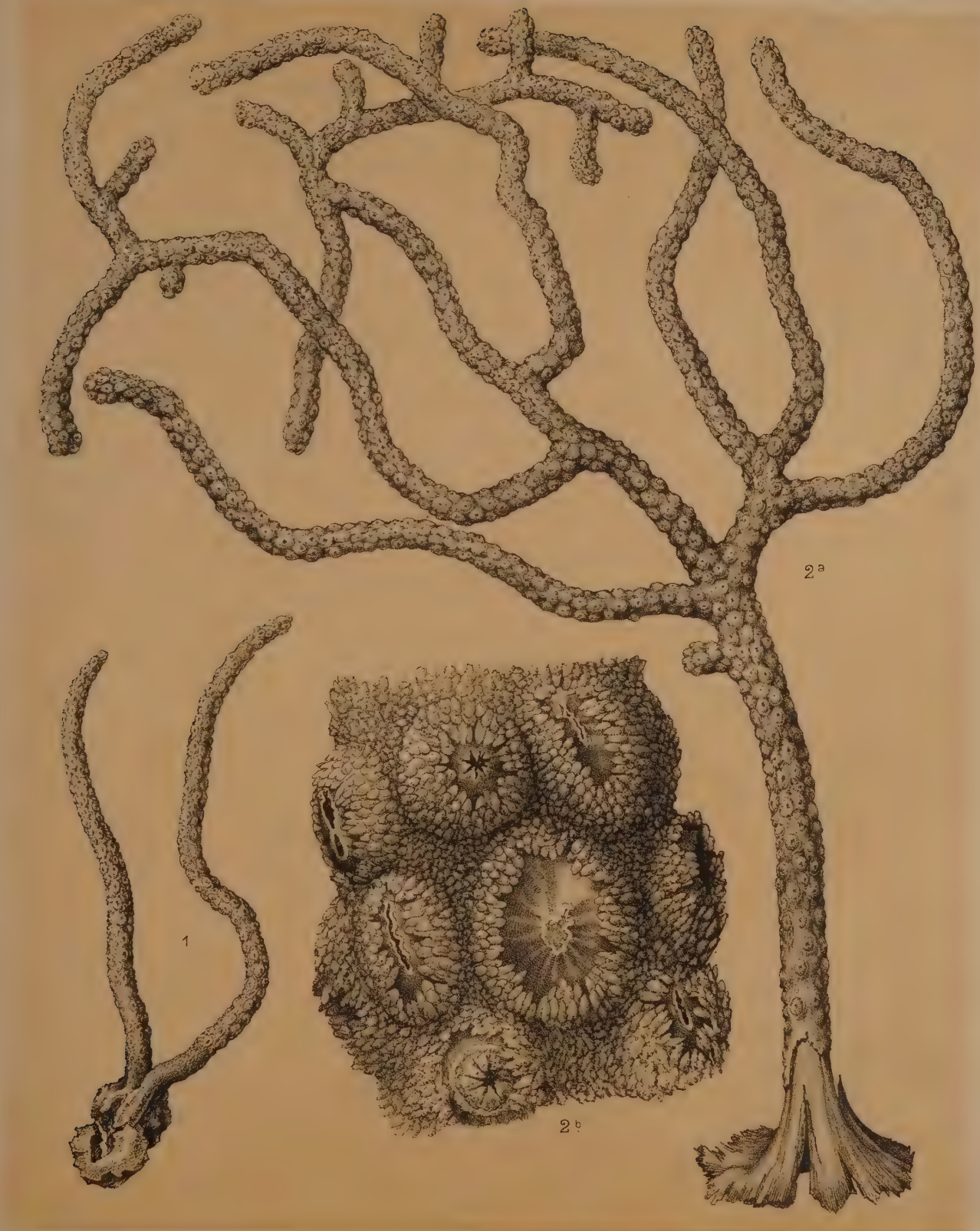
Fig. 1. *Echinogorgia modesta*, n. sp.

Four times nat. size.

Fig. 2. *Eunicea palmata*, n. sp.

Fig. 2*a*. Colony; nat. size.

Fig. 2*b*. Portion of twig with polyps; enlarged.



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ECHINOGORGIA. EUNICEA.

PLATE V.

PLATE V.

Spicules of the newly described species.

Fig. 1. *Telesto* (*Carijoa*) *trichostemma* (Dana).

Fig. 2. *Siphonogorgia pendula*, n. sp.

Fig. 3. *Siphonogorgia köllikeri*, Wright and Studer.

Fig. 4. *Siphonogorgia pustulosa*, n. sp.

Fig. 5. *Siphonogorgia pallida*, n. sp.

Fig. 6. *Anthogorgia japonica*, n. sp.

Fig. 7. *Bebryce philippii*, n. sp.

Fig. 8. *Echinogorgia modesta*, n. sp.

Fig. 9. *Eunicea palmata*, n. sp.

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TELESTO (CARIJOA). SIPHONOGORGIA. ANTHOGORGIA. BEBRYCE. ECHINOGORGIA. EUNICEA.

PLATE VI.

PLATE VI.

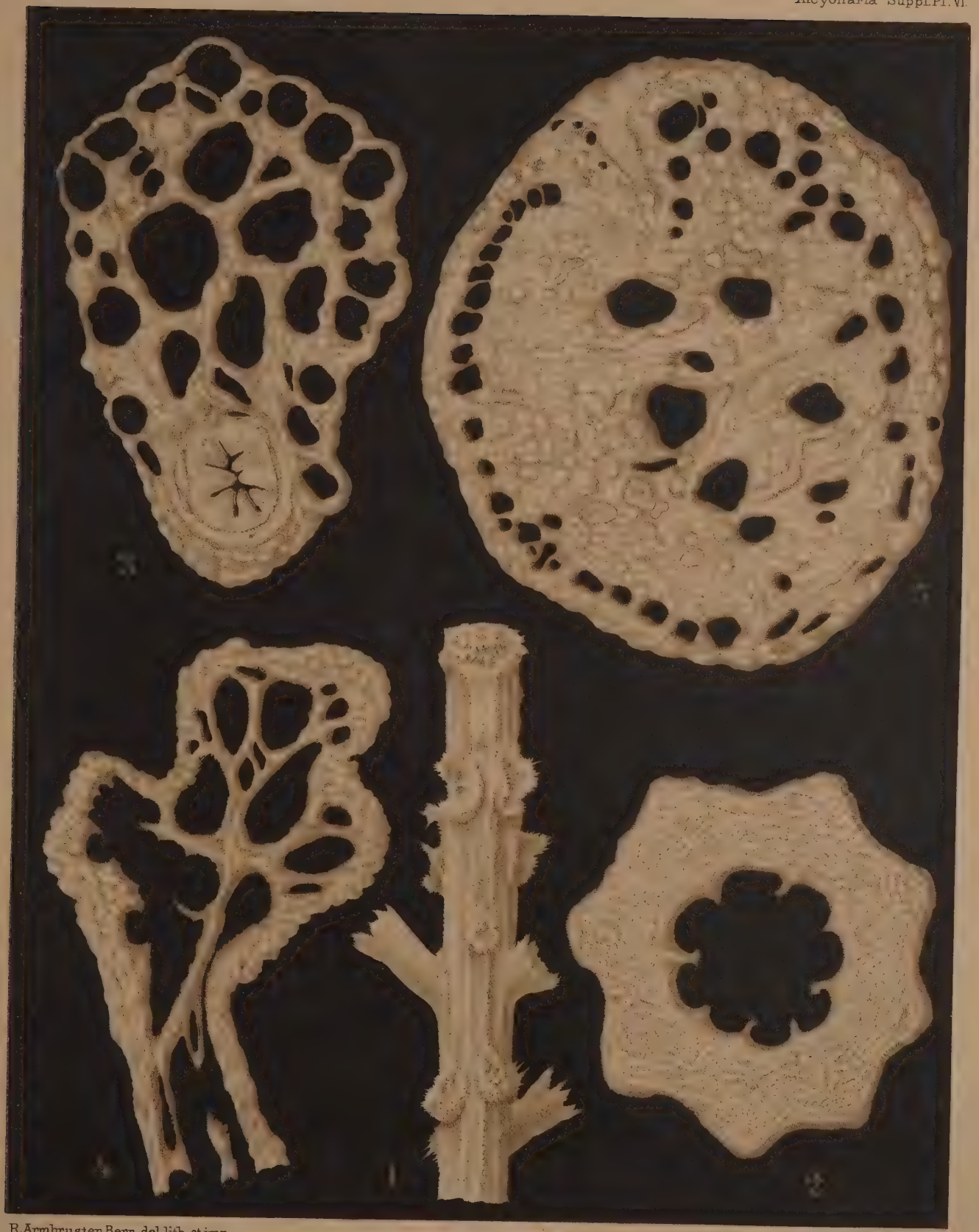
Fig. 1. Skeleton cylinder of *Telesto* (*Carijoa*) *trichostemma* (Dana), after the removal of the softer parts by caustic potash.

Fig. 2. Transverse section through axial polyp of *Telesto* (*Carijoa*) *trichostemma* (Dana).

Fig. 3. Transverse section through a twig of *Siphonogorgia pallida*, n. sp.

Fig. 4. Transverse section through a twig of *Siphonogorgia köllikeri*, Wright and Studer.

Fig. 5. Transverse section through the stem of *Siphonogorgia köllikeri*, Wright and Studer.



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TELESTO (CARIJOA). SIPHONOGORGIA.

THE

VOYAGE OF H.M.S. CHALLENGER.

ZOOLOGY.

REPORT on the Deep-Sea Keratosa collected by H.M.S. Challenger during the Years 1873–76. By Ernst Haeckel, M.D., Ph.D., Hon. F.R.S.E., &c., Professor of Zoology in the University of Jena.

PREFACE.

The remarkable organisms which are described in the following pages were handed over to me by Dr. John Murray partly in 1887, partly several years ago, when I was occupied with the examination of the Radiolaria collected by H.M.S. Challenger. The fact that in the majority of these deep-sea organisms the main mass of the body was composed either of siliceous Radiolarian tests or of calcareous Foraminifera shells, cemented together by an organic substance, was of peculiar interest to me, inasmuch as it had led to the expression of very different opinions by the naturalists who had previously examined them. Several spongiologists (among them some well-known authorities) had denied their sponge-nature, and declared that these peculiar objects were either Rhizopods or other Protozoa. Other naturalists, on the contrary, who were closely acquainted with the Rhizopods, could not acknowledge their Rhizopod nature, neither could they make out the class to which they belonged.

A closer comparative examination of these doubtful organisms of the deep sea has led me to the conviction that they are true sponges, for the most part modified in a peculiar manner by the symbiosis with a commensal organism which is very probably in most cases (if not in all) a Hydropolyp stock. At least the majority of the specimens, I have no doubt, are true Keratose Sponges, although the state of preservation was too imperfect for the recognition of all the finer structures, especially the characteristic

flagellated chambers of the sponges. Perhaps I might not have arrived at that conclusion had I not, ten years before, examined a number of Australian arenaceous sponges, which seem to be closely allied to these deep-sea inhabitants collected by the Challenger in different parts of the world. At that time I was engaged with the Monograph of the Medusæ, and therefore offered the description of those Spongelidæ or Dysideidæ to my friend and pupil, Professor William Marshall of Leipsic. He has given a full description and figures in the Zeitschr. f. wiss. Zool., Band xxxv., 1880.

Dr. John Murray, who, during the cruise of the Challenger, had seen these Deep-sea Keratosa immediately after capture, had at once and rightly recognised their sponge-nature. I find in his handwriting on the labels of the bottles in which all the large forms are preserved the title "Sponges," but afterwards another naturalist crossed this name out and wrote "Large Rhizopods."

Dr. Poléjaeff, of Odessa, commences his Report on the Keratosa collected by H.M.S. Challenger (Zool. Chall. Exp., vol. xi., part xxxi.) with the following words:—"The Keratose Sponges do not belong to the deep-sea fauna." This statement must now be given up in every case. The number of Deep-sea Keratosa described in this Report extends to eleven genera, with twenty-six species, all of which are new, more than half the number (34) distinguished by Poléjaeff among the Keratosa collected by the Challenger in shallow water; of these twenty-one were new. Whilst all these latter belong to genera previously known, the majority of the new deep-sea species belong to new genera, and some of them exhibit such a peculiar organisation that they may represent some new subfamilies, or even families, among the Keratosa. Twenty-three of the twenty-six species were taken in depths between 2000 and 2900 fathoms; three only (Psamminidæ) in depths between 1000 and 2000 fathoms. I suppose that some of the gigantic Foraminifera of the deep sea, which Mr. H. B. Brady has described in his Report as Astrorhizidæ (especially *Rhabdammina*, *Rhizammina*, *Sagenella*, &c.), may also belong to the arenaceous Keratosa (Ammoconidæ).

The results of my examination of the Deep-sea Keratosa, which are given in the following Report, were communicated to the Medicinisch-Naturwissenschaftliche Gesellschaft in Jena on the 14th December 1888.

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INTRODUCTION.

Methods of Examination.

Considering the peculiar organisation of the Deep-sea Keratosa, and the fact that some distinguished spongiologists had denied their sponge-nature, I was, of course, obliged to employ all possible methods of examination, in order to show their sponge-organisation as clearly as possible. A great number of microtomical sections through the different parts of the sponges were mounted, and stained with carmine, hæmatoxylin, methyl-green, and other colouring matters of modern histology. The sponges were besides examined in the dry and the wet state, in glycerine and Canada-balsam, treated with alkalies, mineral acids, &c. Employing these different methods, it has been possible to show conclusively the presence of a true sponge-skeleton in the majority of the Deep-sea Keratosa, as in the two families of the large-sized Stannomidæ and Spongelidæ (Pls. I.–VI.). The results of this examination were different in two other families, the Psamminidæ (Pl. VII.) and the Ammoconidæ (Pl. VIII.); these produce no sponge-skeleton, and are therefore, strictly speaking, not true Keratosa (in the proper sense of the term), but skeletonless Malthosa (or Myxospongiæ).

The most important part of the sponge-organism—as is well known—is the aquiferous canal-system with its characteristic dermal pores (Porifera). Special care, therefore, was taken to recognise its structure in the Deep-sea Keratosa as fully and exactly as possible. But, unfortunately, I was not able to accomplish this part of my task so satisfactorily as could be desired, for three reasons: first, the insufficient state of preservation; second, the enormous mass of xenophya or of foreign bodies, which makes up the greatest portion of all these sponges, covering and hiding the finer structures; third, the peculiar symbiosis with Hydroids, the reticular hydrorhiza of which traverses the whole body in the majority of the Deep-sea Keratosa.

The state of preservation, as well of the Deep-sea Keratosa themselves as of the symbiotic Hydroids connected with them, was in all the specimens of the Challenger collection very insufficient, though probably they were put in strong alcohol soon after capture. No doubt the principal cause of this is the sudden change of conditions (temperature, pressure, &c.) by which these delicate organisms are injured in the most

violent manner, being brought up from depths between 2000 and 2900 fathoms to the surface within a few hours. Even many deep-sea animals of much stronger texture are so injured by this sudden change that their soft tissues are more or less destroyed. The same must be the case in a much greater degree with such delicate tissues as the epithelia of Sponges and Hydroids.[1] A natural consequence of this circumstance is the fact that in all the Deep-sea Keratosa the epithelia (exodermal as well as entodermal) were more or less destroyed. No trace could be found anywhere of the outer covering pavement-epithelium of the exoderm. The peculiar flagellated epithelium of the entoderm was not distinctly recognisable in most of the specimens, and not fitted for finer examination; in several species, however, its presence could be made out with certainty. The state of preservation was generally better in the structures of the mesoderm and in the skeleton.

Families of the Keratosa.

The numerous and very different forms of sponges, which are united by modern authors under the name Keratosa or Ceratina (Horny Sponges, Hornschwämme in German), are divided into a great number of genera, and these again collected into a small number of families. The characters and affinities of these families must be discussed here to a certain extent, seeing that only two of the four families in which I have disposed the Deep-sea Keratosa agree with those of shallow water, the other two being perfectly new.

Poléjaeff is the only modern author who holds that "the whole group of Keratosa is nothing more than a single family." He expresses this singular opinion in a very decisive manner, both in his Report on the Keratosa[2] and in his general notes on the Horny Sponges, incorporated in the Narrative of the Cruise.[3] These conceptions of Poléjaeff, as also many of his other systematic views, are quite incompatible with the phylogenetical principles of modern classification; they are, in my opinion, quite unnatural and dogmatical. This will be demonstrated in the remarks on classification, in the Appendix to this Report. Since no other spongiologist will follow the view of the Russian spongiologist, it need not be here refuted.

Two well-known spongiologists, Lendenfeld and Vosmaer, published independently in the year 1887 the Prodromus of a new sponge-system, and since their opinions agree in the most important points, we may here consider together their classification of the Keratosa, passing over all the former attempts, which are critically discussed in the

[1] Compare the remarks on *Monocaulus* by Sir Wyville Thomson, in the Report on the Hydroida by Allman (Zool. Chall. Exp., pt. lxx. p. 6).

[2] Zool. Chall. Exp., pt. xxxi. p. 81.

[3] Narr. Chall. Exp., vol. i. p. 643.

historical introduction given by Vosmaer.[1] Lendenfeld[2] divides the order Keratosa (Bowerbank) into two suborders (called by him tribus[3]), and these into six families, viz.:—

I. Microcameræ, with small spherical ciliated chambers and opaque ground-mass (1. Family Spongidæ (=Euspongidæ), 2. Family Aplysinidæ, 3. Family Hircinidæ).

II. Macrocameræ, with large sac-shaped ciliated chambers and soft transparent ground-mass (4. Family Spongelidæ, 5. Family Aplysillidæ, 6. Family Halisarcidæ).

Vosmaer adopts only four families among his Ceratina, viz.:—1. Spongelidæ, 2. Spongidæ (=Euspongidæ), 3. Aplysinidæ, 4. Darwinellidæ (=Aplysillidæ, Lendenfeld). These latter are distinguished by dendritic spongin-fibres not anastomosing, while the branched spongin-fibres in the three former families anastomose and form a reticular skeleton. Among these the Spongelidæ possess a soft transparent ground-mass (or maltha), not granular, whilst it is granular and opaque in the Euspongidæ and Aplysinidæ. These two families differ again in the structure of the anastomosing spongin-fibres, which are homogeneous, with a thin axial thread in the Euspongidæ, whereas they are heterogeneous, tubular, with an axial pith-substance in the Aplysinidæ.

A single family only of those enumerated is represented among the Deep-sea Keratosa collected by the Challenger. This is the family Spongelidæ (with two new genera, *Cerelasma* and *Psammophyllum*). The sandy Keratosa, *Psammopemma* and *Holopsamma*, hitherto united with the Spongelidæ, must be separated from them, since they produce no spongin at all; they compose (together with the new genus *Psammina*) our family Psamminidæ. A new family is formed by the remarkable Stannomidæ, the largest and most striking among the Deep-sea Keratosa; their spongin-skeleton is never reticular, but formed by bundles of delicate fibrillæ, which never anastomose; the sandy xenophya are not enclosed by the fibres, but lie between them in the maltha. Not less interesting is a fourth new family, that of the Ammoconidæ, distinguished from all the others by the simple structure of their canal-system, formed on the *Ascon*-type.

Respecting this latter most important difference, all the Deep-sea Keratosa collected by the Challenger belong to two main groups of very unequal range, and these correspond perfectly to the two orders or main groups of calcareous sponges which Dr. Poléjaeff, in his Report on the Calcarea[4] dredged by H.M.S. Challenger, has distinguished as Homocœla and Heterocœla. The first order (Cannocœla) is represented by only a few, and small, but most interesting Keratosa, constituting our

[1] Vosmaer, Bronn's Klassen und Ordnungen des Thier-Reichs, ed. 2, Bd. ii. (Porifera), pp. 17–109, 1887.

[2] Lendenfeld, On the Systematic Position and Classification of Sponges, *Proc. Zool. Soc. Lond.*, December 21, 1886; Der gegenwärtige Zustand unserer Kenntniss der Spongien, *Zool. Jahrb.*, 1887, p. 511.

[3] The term *tribus* is generally employed for smaller sections of a family, therefore subordinate to the latter term. Compare my Generelle Morphologie, Bd. ii. p. 400, Berlin, 1866.

[4] Zool. Chall. Exp., pt. xxiv. p. 35.

family Ammoconidæ (Pl. VIII.). They correspond to the Homocœla or Asconidæ among the Calcarea, and are, like these, thin-walled porous tubules, "without separate flagellated chambers, the whole of the inner surface being covered with flagellated cells."[1] The different forms of these Cannocœla, which I could distinguish, may be disposed into three different genera (*Ammolynthus*, *Ammosolenia*, and *Ammoconia*), and these correspond to the three genera which I have described in my Monograph of the Calcisponges as *Olynthus*, *Leucosolenia* (or *Soleniscus*), and *Auloplegma*.

All the other Keratosa of the deep sea are of larger size, and belong to the second order, Domatocœla. They correspond to the calcareous Heterocœla of Poléjaeff, and possess, like these, "separate flagellated chambers lined with flagellated cells, the remaining parts of the inner surface being covered with pavement-epithelium." The Domatocœla of the deep sea may be disposed into three different families: Psamminidæ, Spongelidæ, and Stannomidæ. The Psamminidæ (*Psammina*, *Holopsamma*, *Psammopemma*) produce no spongin-fibres; their pseudo-skeleton is composed of xenophya or of foreign bodies, which are crowded in the ground-mass of the mesoderm. The Spongelidæ (*Cerelasma*, *Psammophyllum*) possess a network of spongin-fibres which enclose foreign bodies. The Stannomidæ, finally, are distinguished by fine bundles of fibrillæ, between which the xenophya are crowded in the maltha (*Stannophyllum*, *Stannarium*, *Stannoma*).

Synopsis on the Four Families of Deep-Sea Keratosa.

I. CANNOCŒLA. Tubular canal-system, on the Asconal-type (similar to the Asconidæ).	No spongin-skeleton.	Pseudo-skeleton composed of xenophya, which are crowded in the maltha, ...	1. AMMOCONIDÆ.
II. DOMATOCŒLA. Vesicular canal-system, on the Leuconal-type, with larga flagello chambers (similar to the Spongelidæ).	No spongin-skeleton.	Pseudo-skeleton composed of xenophya, which are crowded in the maltha, ...	2. PSAMMINIDÆ.
	Spongin-skeleton composed of horny fibres, fibrillæ or lamellæ.	Spongin-skeleton reticular, composed of anastomosing fibres, including xenophya, . . .	3. SPONGELIDÆ.
		Spongin-skeleton fibrillar, composed of fibrillæ, not anastomosing, and never including xenophya, .	4. STANNOMIDÆ.

[1] *Loc. cit.*, p. 35.

Bathymetrical Table of the Deep-Sea Keratosa.

Family I. Ammoconidæ (Pl. VIII.).

Number of Plates and Figures.	Genus. Species.	Locality.	Challenger Station.	Depth in Fathoms.	Xenophya (or foreign bodies of the pseudo-skeleton).	General Form of the Sponge.	Maximum Size in Millimetres.	Symbiotic Hydroids.
VIII., 1.	*Ammolynthus prototypus.*	Tropical Pacific.	271	2425	Radiolarian ooze.	Simple tubes.	10	O.
VIII., 2.	,, *haliphysema.*	,, ,,	270	2925	Globigerina ooze.		20	O.
VIII., 3.	*Ammosolenia rhizammina.*	,, ,,	216	2000	,, ,,	Branched tubes.	12	O.
VIII., 4.	*Ammoconia auloplegma.*	Tropical Atlantic.	89	2400	,, ,,	Reticular framework.	16	O.
VIII., 5.	,, *sagenella.*	North Pacific.	256	2950	Red clay.		20	O.

Family II. Psamminidæ (Pl. VII.).

VII., 1.	*Psammina plakina.*	South Atlantic.	331	1715	Globigerina ooze.	Discoidal plate.	12	O.
VII., 2.	,, *globigerina.*	Tropical Pacific.	220	1100	,, ,,		30	S.
VII., 3.	,, *nummulina.*	,, ,,	274	2750	Radiolarian ooze.		15	S.
VII., 7.	*Holopsamma cretaceum.*	North Atlantic.	70	1675	Globigerina ooze.	Massive, tuberose.	50	O.
VII., 6.	,, *argillaceum.*	South Pacific.	294	2270	Red clay.		22	O.
VII., 4.	*Psammopemma radiolarium.*	Tropical Pacific.	272	2600	Radiolarian ooze.	Massive, lumpy.	20	O.
VII., 5.	,, *calcareum.*	Tropical Atlantic.	89	2400	Globigerina ooze.		25	O.

Family III. Spongelidæ (Pls. IV., V., VI.).

VI., 1–5.	*Cerelasma gyrosphæra.*	Tropical Pacific.	271	2425	Radiolarian ooze.	Reticular framework.	70	S.
VI., 6, 7.	,, *lamellosa.*	,, ,,	216	2000	Sponge-spicules.		20	S.
V., 1–5.	*Psammophyllum reticulatum.*	,, ,,	198	2150	,, ,,		90	S.
IV., 5–8.	,, *flustraceum.*	North Pacific.	241	2300	Radiolarian ooze.	Flabelliform leaf.	105	S.
IV., 1–4.	,, *annectens.*	,, ,,	244	2900	,, ,,		75	S.

Family IV. Stannomidæ (Pls. I., II., III.).

I., 1; II., 1.	*Stannophyllum zonarium.*	Tropical Pacific.	271	2425	Radiolarian ooze.	Flabelliform.	60	S.
I., 2.	,, *radiolarium.*	,, ,,	,,	,,	,, ,,	,,	50	S.
I., 3.	,, *pertusum.*	,, ,,	,,	,,	Partly Radiolarian ooze, partly Globigerina ooze.	,,	120	S.
I., 4.	,, *venosum.*	,, ,,	,,	,,		,,	250	S.
I., 5.	,, *globigerinum.*	,, ,,	,,	,,		,,	90	S.
III., 6–9.	*Stannarium alatum.*	,, ,,	272	2600	Radiolarian ooze.	Composed of branched leafs.	60	S.
III., 10–14.	,, *concretum.*	,, ,,	270	2925	Globigerina ooze.		50	S.
III., 1–4.	*Stannoma dendroides.*	,, ,,	271	2425	Radiolarian ooze.	Arborescent.	50	S.
III., 5.	,, *coralloides.*	,, ,,	272	2600	,, ,,	Coralliform.	40	S.

Bathymetrical Table.

The bathygraphical distribution of the Keratosa appears very much altered by the results of this Report, as is exhibited by the preceding complete list of the twenty-six Deep-sea Keratosa here described, with notes on the localities and some general qualities. Dr. Poléjaeff, in his Report on the Keratosa,[1] has added a bathymetrical table (also adopted by Vosmaer in Bronn's Klassen und Ordnungen, 1887, p. 455). This table shows that most of the Keratosa are inhabitants of shallow water, and that no single species goes down deeper than 400 fathoms.

Twenty-three among the twenty-six new Deep-sea Keratosa here described are taken from depths between 2000 and 2950 fathoms, three only (Psamminidæ) in depths between 1100 and 2000 fathoms. Twenty-two species are found in the Pacific (eighteen in the Tropical Pacific), and only four in the Atlantic.

[1] *Loc. cit.*, p. 73.

GENERAL REMARKS ON THE ORGANISATION OF THE DEEP-SEA KERATOSA.

The general organisation of the sponges is widely discussed in the voluminous and most valuable reports on the various main groups of this class, which form such an important part of the Challenger work, viz. :—Sollas on the Tetractinellida (Zool. Chall. Exp., part lxiii. vol. xxv., 1888), F. E. Schulze on the Hexactinellida (Zool. Chall. Exp., part liii. vol. xxi., 1887), Ridley and Dendy on the Monaxonida (Zool. Chall. Exp., part lix. vol. xx., 1887), Poléjaeff on the Keratosa (Zool. Chall. Exp., part xxxi. vol. xi., 1884), and Poléjaeff on the Calcarea (Zool. Chall. Exp., part xxiv. vol. viii., 1883). The greatest part of the general morphological and physiological considerations which are given in this rich series of reports, and mainly in those of Sollas and F. E. Schulze, may be accepted also for the small group of sponges which are described here as Deep-sea Keratosa. To avoid repetitions, therefore, it is sufficient to refer to the last-named reports, and to add here only a few short remarks on those peculiarities which deserve special attention in the organisation of the horny sponges of the deep sea.

Individuality and External Form.

The external form of sponges, as is well known, is extremely variable, and is generally of little morphological importance, since often sponges of very different internal structure possess the same external form, and, on the other hand, often two closely allied sponges are quite different in external shape. This is easily explained if we consider as the simplest individual sponge the *Olynthus*, or a Gastræa-like simplest tubular person, and if we assume that the body of most sponges is a corm or stock composed of numerous such persons, viz., the flagellated chambers (or, in the Asconidæ and Ammoconidæ the equivalent branches of the tubular body). The external form of the corms or stocks (in contradiction to that of the component persons) is very variable, and subject to adaptation also in other classes of corm-building lower animals, *e.g.*, in the closely-allied Hydroids and Corals (Hydrozoa and Anthozoa). When we compare the single individuals (persons or zooids) of a massive corm of Hydroids or Corals and the

corresponding individuals of sponges (the flagello-chambers), we find similar relations between the associated persons and their large community. The variable manner in which the persons or zooids are connected and arranged, and in which the common canal-system of the community (the cœnenchyma) is developed, often shows a striking similarity in both cases.

The theory that the true primordial form of all sponges was an *Olynthus*, and that all the other forms were developed from an *Olynthus* stage (*Olynthula*), was first stated in 1872 in my Monograph of the Calcispongiæ (in connection with the Gastræa theory), and has now been accepted by most modern spongiologists, by F. E. Schulze, Sollas, Lendenfeld, Vosmaer, Marshall, Keller, and others. Many of these recent observers have demonstrated the existence of a homologous larval form (*Olynthula*) in the ontogeny of very different sponges. But ripe and fully-developed sponges, which persist in the primitive *Olynthus* form, and produce in this form eggs and sperm, were known hitherto only among the Calcarea (*Calcolynthus*).[1] It is therefore a fact of general interest that among the Deep-sea Keratosa collected by the Challenger, there occurs a small ripe sponge (with eggs) which seems to be a true horny *Olynthus* (or, more strictly speaking, an arenaceous *Olynthus*), the remarkable *Ammolynthus* figured in Pl. VIII. figs. 1, 2. Unfortunately the delicate soft parts of the tissues, in this as well as in all the other Deep-sea Keratosa, were very badly preserved, so that the histological evidence of its true nature could not be demonstrated with all the desirable certainty.

Regarding the *Olynthus* as the simple sponge individual or zooid (Gastræa), and as equivalent or homologous to a single tubular branch in the Homocœla, and to a single flagello-chamber in the Heterocœla, we must regard all other sponge-forms as corms, composed of numerous Olynths. They exhibit the same relation to *Olynthus* as the various Hydroid corms bear to *Hydra*. The external form of these corms or stocks in the Deep-sea Keratosa has the same variability and wide divergence as in the other groups of the class. This is especially the case in the smaller forms, the Ammoconidæ and Psamminidæ, where we find irregular, crusty, and massive corms, flat discs, tuberose lumps, branched and reticular stocks, &c. Among the larger Keratosa of the deep sea the prevailing and most common form is that of a thin flabelliform leaf (*Stannophyllum*, Pl. I.; *Psammophyllum*, Pls. IV., V.). This form (rarely occurring in other sponges) is remarkable for its perfect bilateral symmetry (or, strictly speaking, the amphithect ground form). The regular symmetry is especially striking in those forms in which branched ribs are disposed on both sides (Pl. I. figs. 3, 4; Pl. IV. fig. 5). The two flat sides of the reniform leaf exhibit constantly the same structure; it is therefore probable that these flabelliform sponges arise vertically from the sea-bottom, attached by the slender pedicle, which is inserted in the middle of the basal concave margin.

[1] See pl. i., pl. vi. fig. 1, pl. xi. figs. 6–9, pl. xiii., &c., in my Monograph.

Histology.

The tissues of the sponges are now generally regarded as derived from two simple epithelial layers, which I first compared with the two primitive germ layers of the other Metazoa, exoderm (or ectoderm) and entoderm (or endoderm), in my Monograph of the Calcispongiæ (1872). From this comparison, and from the deduced homology of the Gastrula form in all Metazoa, arose my Gastræa theory. At that time I was of the opinion that in all sponges these two primitive cell-layers were metamorphosed in a similar manner, the inner (entoderm) lining as a simple permanent epithelium the cavities of the gastral canal-system, and producing the sexual cells, whilst the blending cells of the outer layer (exoderm) melt together and form a syncytium, or a contractile protoplasmic ground-mass (sarcodine), in which the scattered nuclei of the cells are propagating; in this syncytium, too, the skeleton is formed.

Three years later (in 1875) this conception was corrected by the accurate observations of Franz Eilhard Schulze, the excellent spongiologist, who has advanced in so many important directions the knowledge of this class of Cœlenterata. Employing new methods of histological examination, he discovered on the surface of many sponges a delicate external pavement-epithelium not before observed, and deduced from this observation the following important conclusions :—

The body of the sponges is originally composed not of two, but of three primitive cell-layers, corresponding to those which in the higher organised Metazoa are called exoderm, mesoderm, and entoderm. The exoderm (or outer layer covering the external faces) and the entoderm (or inner layer lining the canal-system internally) are two simple epithelial plates, and between them is enclosed the mesoderm (or the middle layer); this latter is a kind of connective tissue, and produces not only the skeleton, but also the sexual cells (eggs and sperm).

The conception of the sponge-tissues given by F. E. Schulze is now generally accepted, and it is very probable that it has general value, though it was not possible to demonstrate clearly in all sponges the delicate exodermal epithelium. The histological examination of our Deep-sea Keratosa has given no remarkable and positive results in this respect, owing to their insufficient state of preservation. I will not, therefore, further discuss their finer histological structure, but only add a few remarks on the three above-mentioned layers.

Exoderm (Surface-Epithelium).—The delicate simple epithelium, composed of thin pavement-cells, which F. E. Schulze discovered on the surface of many sponges, is now usually regarded as an independent cell-layer, and often compared with the epidermis of the higher Metazoa. This conception may be combated even when we assume its general presence in all sponges (which is not proved). In my opinion this outer exodermal epithelium does not possess the same primary importance and independence as

the inner entodermal epithelium of the canal-system. Comparing the descriptions which are given of the former in many different sponges, I am more inclined to regard it as a superficial epithelial differentiation of the mesoderm, with which it remains in closest connection. The fact that the main mass of the sponge-body (or the so-called mesoderm) belongs histologically to the connective tissue, is not in contradiction with its conception as exoderm. We know that the peculiar mantle of the Ascidiæ is a voluminous and most remarkable product of the exoderm; it is a true connective tissue in histological respect, but a true exodermal (not mesodermal!) production in genetical respect. The cells, which are scattered in the connective ground-mass of the Ascidian tunic, and which are derived from the epidermis (!), are often arranged on the outer surface of the thickened tunic in the form of an outer simple layer of pavement-cells (a quasi-secondary epidermis). This may be compared to the surface-epithelium of the sponges. The histological comparison of the tunic of the Ascidiæ with the so-called mesoderm of the sponges seems to be justified, especially as the further differentiation of both of them is often very similar.

Entoderm (Canal-Epithelium).—In opposition to the exodermal surface-epithelium, which we may regard only as a secondary superficial production of the primary outer cell-layer, the entodermal epithelium of the canal-system is independent from the beginning, a self-subsistent inner group of cells, which is separated already in the Gastrula from the different exodermal group (the fundament of the later mesoderm and the secondary exoderm). This entodermal or gastral epithelium seems to have in the Keratosa—and similarly in the Calcarea—two modes of development. It remains as a single continuous layer of flagellated cells through all the cavities of the canal-system in the Ammoconidæ (Pl. VIII.), closely agreeing with the Asconidæ (Asconal-type). It is differentiated into two very different portions in all the other Keratosa, the canal-system of which is developed on the Leuconal-type (as in the Leuconidæ). The flagellated epithelium remains here restricted to the flagello-chambers, whilst the entoderm in all the other parts of the canal-system is a simple flat pavement-epithelium.

Mesoderm.—The main mass of the sponge-body, which is usually now called the mesoderm, and which we derive from the original primitive exoderm, exhibits in the various sponges, as is well known, an infinite variety of detailed structure, mainly in the production of the skeleton. Regarded histologically, the mesoderm is always a kind of connective tissue or malthar tissue,[1] and exhibits similar manifold differentiations to those of the higher Metazoa. It is a relatively thin lamellar plate in the Ammoconidæ (as also in the Asconidæ), whilst it becomes massive and voluminous in the other Keratosa (as in the majority of sponges). We distinguish in the malthar tissue of the Keratosa (as in the various connectiva of other sponges) the following constituents:—

[1] On the conception of malthar tissue (Maltha) and its distinction from fulcral tissue (Fulcrum), compare the Report on the Deep-sea Medusæ (Zool. Chall. Exp., pt. xii. vol. iv. § 50, p. xxxi).

(I.) The common ground-mass or maltha; (II.) the cells scattered in the maltha; and (III.) the various skeletal productions. The cells scattered in the maltha belong in our Keratosa to three different groups, viz., (1) malthocytes or collencytes (usual connective cells); (2) amœbocytes (amœboid wandering cells); and (3) gonocytes, or sexual cells (eggs and sperm).

Maltha.—The common ground-mass of the connective tissue, which we call shortly maltha, is usually described as ground-mass, matrix, intercellular substance, mesoglœa, collenchyma, &c. It is secreted by the connective cells of the mesoderm, which are derived originally from the primary exoderm cells. Those spongiologists who have especially examined the Keratosa (F. E. Schulze, Lendenfeld, Poléjaeff, and others) distinguish in this group two different main forms of the maltha; it is clear and transparent in the Macrocameræ (Spongelidæ and Darwinellidæ), and granular and opaque in the Microcameræ (Euspongidæ and Aplysinidæ). All the Keratosa of the deep sea (as far as the maltha is well preserved) seem to agree in this respect with the Spongelidæ; their mesodermal ground-mass is clear and transparent, in most species soft, scantily developed, and not voluminous.

Malthocytes or Collencytes.—The common cells of the connective tissue, which produce the maltha or matrix of it by secretion, are not very abundant in the Deep-sea Keratosa, and may be easily overlooked in the examination of the scanty maltha, owing to the predominant masses of xenophya filling up the latter. The best objects for their examination (as for that of the maltha in general) are those Keratosa in which the xenophya are calcareous, derived from Globigerina ooze. Having dissolved the calcareous matter by dilute acids, there remains a soft and transparent maltha, in which the small malthocytes are scattered irregularly. Their form is usually stellate or spindle-shaped, with a small granular ovate nucleus, a little protoplasm, and a few short pointed apophyses.

Amœbocytes.—The remarkable amœboid wandering cells, which seem to possess an important physiological function in all sponges, are also found in our Deep-sea Keratosa. They are scattered in the maltha in far less numbers than the malthocytes, and may easily be distinguished from them by the larger size of the protoplasmic cell-body as well as of the clear vesicular nucleus. The more voluminous protoplasm usually encloses a variable mass of dark, highly refracting, and intensely staining granules, and often these enter in the lappet-like processes, or lobopodia of the cell, as in the similar common Amœbæ. The Amœbocytes of the sponges are comparable to the Leucocytes of the higher Metazoa, and are probably derived from the original, not differentiated, exoderm cells. Their functions are probably multifarious, referring mainly to the nutrition of the sponge. They may be vehicles of food and of reserve nutriments. But in the Stannomidæ they may also produce the peculiar spongin-fibrillæ of this family, comparable to odontoblasts which produce dentin fibrillæ.

Gonocytes (Eggs and Sperm).—It was very important to demonstrate that our Deep-sea Keratosa develop eggs in the mesoderm, in order to show that they are true sponges, and not large-sized Rhizopods. At first I vainly searched for them for a long time; but finally I succeeded in finding eggs in single specimens of all four families—in *Ammolynthus prototypus* among the Ammoconidæ (Pl. VIII. fig. 1C, *e*), in *Psammina plakina* among the Psamminidæ (Pl. VII. fig. 1D, *e*), in *Psammophyllum flustraceum* among the Spongelidæ (Pl. V. fig. 5, *e*), and in *Stannophyllum globigerinum* among the Stannomidæ. The eggs were in all these cases of the same indefinite form and size as in the other Keratosa, where they are described so well by F. E. Schulze and others. They lie scattered in the maltha of the mesoderm, and exhibit always the large, clear, subspherical nucleus, with a dark nucleolus, surrounded by the granular protoplasm. The earliest stages of the eggs could not be distinguished from amœbocytes.

It was not possible to distinguish spermatoblasts or ripe sperm in any of the Deep-sea Keratosa, but considering the difficulties in showing their presence even in living and well-preserved sponges, it is easy to conceive that they were not recognisable in our insufficiently preserved spirit-specimens.

Canal-System.

The characteristic gastrocanal-system of the sponges exhibits, as is well known, a great many modifications, which may be disposed in a few main forms or types. In my Monograph of the Calcisponges (1872) I had distinguished three such types, viz.:—1. The Asconal-type (*Ascon*, *Leucosolenia*); 2. The Syconal-type (*Sycon*, *Sycandra*); 3. The Leuconal-type (*Leuconia*, *Leucandra*). Vosmaer, in his recent work on the Sponges (Bronn, 1887), has adopted these three types, and added a fourth type, represented by *Aplysina*, the common sponge, *Euspongia officinalis*, &c. (*loc. cit.*, p. 144); this may be called shortly the Aplysinal-type.

Two of these four principal types are represented among the Keratosa of the deep sea. The canal-system of the new family Ammoconidæ (Pl. VIII.) is constructed on the Asconal-type; that of the three other families (Psamminidæ, Spongelidæ, Stannomidæ) follows the common Leuconal-type. The two peculiar types of canal-system which we call the Syconal-type and the Aplysinal-type, do not occur among the Keratosa here described.

The difference between the simple Asconal-type of the Asconidæ and the complex Leuconal-type of the Leuconidæ (and of the majority of all sponges) is so important that many recent authors have adopted the separation of Poléjaeff, who divides the Calcarea into two orders, Homocœla (Asconidæ) and Heterocœla (all the other Calcispongiæ). Employing the same principle in the Keratosa, we should divide

this legion into two orders, Cannocœla (the Ammoconidæ) and Domatocœla (all the other Keratosa).

The Cannocœla, represented by the Ammoconidæ (Pl. VIII.), retain either the primordial Ascon-type, the *Olynthus*-form (*Ammolynthus*, figs. 1, 2), or they form branched tubular bodies, composed of a few or numerous *Olynthus*-tubules; the branches are either free, each possessing a terminal osculum (*Ammosolenia*, fig. 3), or are connected by anastomoses, and form a reticular framework (*Ammoconia*, figs. 4, 5); the wall of the delicate tubules is in all these Ammoconidæ very thin, supported by a delicate mesoderm-lamella (as in the Asconidæ), and is pierced by small simple pores; the sea-water entering by these pores is propelled by the flagellated collar-epithelium, which lines the whole inside of the tubules, and issues finally either by the distal oscula or by other pores. Each branch of the Ammoconidæ, as well as of the similar Asconidæ, is to be regarded as a secondary *Olynthus*, and at the same time homologous to a single flagellated chamber in the second order, the Domatocœla.

The Domatocœla (corresponding to the Heterocœla in the Calcarea) are represented among the Deep-sea Keratosa by three families, the Psamminidæ (Pl. VII.), the Spongelidæ (Pls. IV.–VI.), and the Stannomidæ (Pls. I.–III.). All the horny sponges hitherto described belong to the Domatocœla. The main mass of their body is formed by a voluminous mesoderm, or a kind of connective tissue, and this is permeated by a complex canal-system. The outer surface of the mesoderm is covered by a delicate pavement-epithelium and pierced by innumerable microscopical pores; the water enters through these pores into ramified canals, and is propelled by the vibratile motion of flagellated entoderm-cells, which line the characteristic "flagellated chambers" disposed in a variable manner along the canals; from these the water issues by canals, which open finally by smaller or larger exhalent openings (oscula). The special structure of this domatocœlous canal-system (as far as it could be recognised in the three families examined) is essentially the same as in the Spongelidæ, with large sac-shaped flagellated chambers (Macrocameræ, Lendenfeld).

Skeleton.

The varied and manifold development of the skeleton, which is the main principle in the classification of the numerous genera and species of sponges, is also in the Deep-sea Keratosa of the greatest importance. It offers, too, here certain remarkable features which are not found in the Keratosa hitherto known, and some peculiarities which are quite new. The causes of this peculiar development may be searched for partly in the peculiar conditions of deep-sea life and the adaptation of the organism to the abyssal bottom, partly in the curious symbiosis, to which the majority of the Deep-sea Keratosa are subject.

Considering as the skeleton—in the usual physiological sense—all those solid parts of the animal body which serve as a supporting frame and as a protecting carapace, we may point out, first of all, that the skeleton of the Deep-sea Keratosa in general is composed of three very different portions, viz., (1) spongin-fibres, produced in the mesoderm of the sponge, and characteristic of all true Keratosa; (2) xenophya, or solid foreign bodies, taken up from the bottom of the deep sea and disposed in the mesoderm; (3) chitinous tubes of Hydroids which live in symbiosis with the majority of our Keratosa. The two latter elements of the skeleton may be better called pseudo-skeleton, since they are foreign bodies not produced by the sponge itself; but they generally possess in our Deep-sea Keratosa a far greater importance than the true skeleton of the sponge itself, composed of its proper spongin-fibres.

The first fact that strikes one in the examination of the Deep-sea Keratosa is the circumstance, that in all cases by far the greatest part of the body is composed of various xenophya, and not of the tissues and organs of the sponge itself. The foreign enclosures are everywhere found in such large masses that their total volume is always far greater than that of all the parts of the sponge proper together. The latter form often scarcely one-third or one-fourth of the whole volume, or less; whilst the xenophya occupy two-thirds or three-fourths, or more. Comparing the weight of the two different body-components, their disproportion, of course, appears far greater. The xenophya being much heavier than the delicate soft tissues of the sponge itself, the weight of the former is probably usually more than 90 per cent., the weight of the latter less than 10 per cent.

The xenophyal skeleton is the only essential part of the skeleton in the two first families, Ammoconidæ (Pl. VIII.) and Psamminidæ (Pl. VII.); whilst it is combined with spongin-fibres, and with symbiotic Hydroid tubes in the two other families, Spongelidæ (Pls. IV.–VI.) and Stannomidæ (Pls. I.–III.). But even in these latter the foreign pseudo-skeleton, composed of the chitinous tubes of the symbiotic hydrorhiza, plays a more important part than the true spongin-skeleton of the sponge itself.

The spongin-fibres in our Deep-sea Keratosa are constantly very thin and small, and scantily developed, far less than in the well-known Keratosa of shallow water. In the former are never found the stout and strong horny main fibres, which erect the firm scaffold of the body in the latter. The place of these main fibres is taken by the chitinous tubes of the symbiotic Hydroids, and this remarkable replacement is evidently a most important consequence of that curious symbiosis. The two families which produce spongin-fibrillæ differ essentially in their relation to the xenophya. These foreign skeletal bodies are enclosed within the maltha alone in the Stannomidæ, while in the Spongelidæ a part of them, at least, is enclosed in the spongin-fibres.

Spongin-Skeleton.—The peculiar pure spongin-skeleton, characteristic of the true Keratosa, is found only in two of our deep-sea families, in the Stannomidæ (Pls. I.–III.)

and the Spongelidæ (Pls. IV.–VI.); it is quite absent in the two other families, the Psamminidæ (Pl. VII.) and the Ammoconidæ (Pl. VIII.). These two latter families therefore are, strictly speaking, not Keratosa (or Ceraspongiæ) but Malthosa (or Myxospongiæ). The important question of the natural relations of these different groups will be discussed in the Appendix.

The Spongelidæ of the deep sea are represented in the Challenger collection by two genera, both differing essentially in the structure of the horny skeleton from the common Spongelidæ of shallow water. The stout and strong main fibres of the horny skeleton, which form the solid scaffold of the body in these latter, are wanting in the former; they are replaced by the chitinous tubes of the symbiotic hydrorhiza. The spongin production is restricted in *Psammophyllum* (Pls. IV., V.) to a framework of very thin branched spongin fibres, forming a delicate network, which is expanded within the meshes of the far stouter network produced by the symbiotic Hydroid. *Psammophyllum* seems to be closely related to the similar Spongelid *Phyllospongia papyracea* (Ehlers), but this shallow-water form possesses the same stout main fibres as the common *Spongelia*.

The other genus of deep-sea Spongelidæ, *Cerelasma* (Pl. VI.), is distinguished from all other genera by the peculiar form of the spongin secretion. The spongin here forms peculiar capsular envelopes around the xenophya, and these are connected by branched lamellæ, which form a loose framework. The more solid reticular framework of the symbiotic hydrorhiza branches everywhere between the meshes of the former, and gives them a firm support.

The new family Stannomidæ (Pls. I.–III.), represented by numerous large forms, forming the most stately portion of the collection here described, differ from all other Keratosa in the peculiar development of the spongin-skeleton. This is composed of innumerable fine yellow threads or fibrillæ, which run in all directions through the mesodermal maltha, partly single, partly associated in bundles. They are usually simple and very long, more rarely branched, and never anastomose. They never enclose xenophya, but run everywhere around and between them. A closer examination shows that they cannot be hyphæ of fungi, or other foreign productions (as was supposed by some naturalists), but that they agree perfectly in chemical nature and anatomical structure with the finer horny fibres of the common Spongelidæ.

Xenophya.[1]—The foreign bodies which compose the pseudo-skeleton of the Deep-sea Keratosa, and which we call briefly "xenophya," differ in composition according to the nature of the bottom on which the living sponges grew. The young sponge naturally takes for the building up of its supporting pseudo-skeleton the xenophya making up the bottom at that locality. The three principal kinds of ooze usually found at the bottom of the deep sea compose accordingly the xenophyal skeleton of our Keratosa, viz., (1) Radiolarian ooze, (2) Globigerina ooze, and (3) red clay. Besides, the inorganic

[1] *Xenophya* = ξενόφυες, foreign bodies.

remains of other organisms which live in the same depths may also be taken up by the growing sponge, as, for instance, the siliceous spicules of Hyalospongiæ, and the calcareous fragments of echinoderms and other lower animals. Among the twenty-six Deep-sea Keratosa here described, ten species possess a siliceous skeleton composed of Radiolarian shells, eight species a calcareous skeleton composed of Foraminifera shells, three species a mineral skeleton, composed of the volcanic particles of red clay, and five species a mixed skeleton, composed of the various elements of the three kinds of ooze and also of various sponge spicules. The disposition of the different skeletal elements in the four families of Deep-sea Keratosa will be seen from the following table :—

Keratosa.	Without spongin-skeleton.		With spongin-skeleton.	
Materials of the pseudo-skeleton taken up from the sea-bottom.	I. Family Ammoconidæ.	II. Family Psamminidæ.	III. Family Spongelidæ.	IV. Family Stannomidæ.
I. Globigerina ooze, ...	3	3	0	2
II. Radiolarian ooze, ...	1	2	2	5
III. Mineral particles of red clay, . .	1	1	1	0
IV. Mixed pseudo-skeleton, with sponge spicules, &c., ...	0	1	2	2

The xenophya fill up the whole maltha in all the Deep-sea Keratosa, and are immediately enclosed by the clear transparent ground-mass of the mesoderm. The family Spongelidæ differs from the other three in having a portion of the xenophya also connected and partly enclosed by the skeletal fibres; in *Psammophyllum* (Pls. IV., V.) the enclosure by the spongin-fibres is similar to that in the common Spongelidæ (*Spongelia*, *Dysidea*, &c.), but in *Cerelasma* each single xenophyum is surrounded by a capsular spongin-envelope, and these are connected by branched spongin-lamellæ, which form a reticular scaffold (Pl. VI.). The new family Stannomidæ differs from all other Keratosa in the peculiar fact, that the whole mesoderm is traversed by innumerable bundles of fine spongin-fibrillæ, but these run between the xenophya and never enclose them (Pls. I.–III.).

Chitinous Tubes of Symbiotic Hydroids.

One of the most remarkable features of our Deep-sea Keratosa, characteristic of the majority of them, is their symbiosis with certain Hydroids. The cylindrical, branched, and anastomosing chitinous tubes, which compose the reticular hydrorhiza of the latter,

traverse the body of these Keratosa in all directions, and replace mechanically the absent scaffold of stout spongin main fibres. This peculiar adaptation is found in sixteen species, viz., in all the Stannomidæ (nine species), in all the Spongelidæ of the deep sea (five species), and in two species of Psamminidæ; the symbiotic Hydroids are wanting in most of the smaller forms, in the remaining five species of Psamminidæ, and in all the Ammoconidæ (five species). A full description of the various symbiotic Hydroids is given in the Appendix. Their chitinous tubes are usually filled by a dark brown mass, which former observers supposed to be the phæodium of a large Rhizopod. Closer examination proved it to be the cœnenchyma, which is usually more or less destroyed, and showed also the gonangia and the hydranths.

DESCRIPTION OF GENERA AND SPECIES.

Family I. Ammoconidæ, n. fam. (Pl. VIII.).

Definition.—Keratosa without spongin-fibres. Pseudo-skeleton composed of xenophya (or manifold foreign bodies), which are disposed in the thin malthar plate of the porous tubular body. Canal-system tubular, developed on the Asconal-type (similar to that of the Asconidæ).

The new family Ammoconidæ, represented in the Challenger collection by three different deep-sea genera, is of extraordinary morphological interest, for it is the first example of a simple so-called "homocœlous structure" among the "Non-calcarea," viz., that most remarkable organisation which is represented by the Asconidæ among the Calcarea. In the first genus, *Ammolynthus*, the body is a simple, unbranched tubule, with an oscular opening at the superior end, opposite to the inferior pedicle (Pl. VIII. figs. 1, 2); it corresponds to *Calcolynthus* among the Calcarea. The second genus, *Ammosolenia*, is a branched or arborescent body, composed of several *Ammolynthus* (Pl. VIII. fig. 3), similar to *Soleniscus*. The third genus, *Ammoconia*, forms a loose, roundish framework, composed of anastomosing tubules, without oscula, similar to *Auloplegma* (Pl. VIII. figs. 4, 5). The thin wall of all these tubular sponges is pierced by simple pores, through which the water enters into the simple gastral cavity; it issues either through these or through larger openings (oscula). Remains of the entodermal flagellated epithelium lining the inside of the tubes were visible in two genera examined, but no trace of an exodermal pavement-epithelium was visible on the outside; it was probably lost, as usual in spirit specimens. The main mass of the thin wall is formed by foreign bodies, or manifold xenophya, Radiolaria, Foraminifera, sand-grains, &c. They are connected by a relatively scarce maltha, or a homogeneous ground-mass, in which the small cells of the connective tissue are recognisable between the xenophya.

Xenophya.—The foreign bodies which compose the pseudo-skeleton of the Ammoconidæ, and which are cemented together by the scanty maltha of the mesoderm, are calcareous in three of the five species examined—shells and fragments of *Globigerina* and allied Foraminifera (Pl. VIII. figs. 2–4). They are siliceous in the two remaining species, Radiolarian tests in one (fig. 1), spicules of siliceous sponges and volcanic mineral particles,

such as are found in the red clay, in the other (fig. 5). Thus it appears that the three principal abyssal deposits—Globigerina ooze, Radiolarian ooze, and red clay—supply accidentally the materials of which the pseudo-skeleton in these Ammoconidæ, as well as in the following families of Deep-sea Keratosa, is composed.

Soft Parts.—Whilst the main mass of the tubular body in all the Ammoconidæ is composed of xenophya, or of foreign bodies received from the ooze of the sea-bottom, the true organic tissue of the sponge itself is represented only by the thin delicate membrane which connects and encloses the xenophya. The nature of this membrane is best recognised in those species in which the calcareous matter may be removed by treatment with acids. The delicate residue is formed by a thin, transparent, or somewhat granular membrane, which closer examination proves to be a soft maltha, or mesodermal ground-mass, in which two kinds of cells are enclosed: small, roundish, fusiform or stellate, connective cells, and larger amœboid wandering cells. Besides, in one species (*Ammolynthus prototypus*, Pl. VIII. fig. 1) larger amœboid cells could be recognised, possessing a large clear spherical nucleus with a small dark nucleolus (figs. 1B, 1C, *e*, *v*). These cannot be distinguished from the common naked eggs of sponges; stages of segmentation, however, and larvæ (Gastrulæ) were not observed in these Ammoconidæ. The same must be said of the (hypothetical) exodermal pavement-epithelium, whereas remnants of the entodermal flagellated epithelium were recognisable on the inside of some tubular Ammoconidæ (Pl. VIII. figs. 1B, 1C, *n*).

Ammoconidæ and Rhabdamminidæ.—The peculiar deep-sea organisms here described as Ammoconidæ exhibit a striking resemblance to certain Rhabdamminidæ, described as Foraminifera Astrorhizida in Henry B. Brady's Report.[1] We find a striking similarity between *Ammolynthus* and *Rhabdammina*, between *Ammosolenia* and *Rhizammina*, between *Ammoconia* and *Sagenella*. Brady thus characterises the family Astrorhizidæ:—"Test invariably composite, usually of large size and monothalamous; often branched or radiate, sometimes segmented by constriction of the walls, but seldom or never truly septate; polythalamous forms never symmetrical."[2] The subfamily Rhabdamminidæ is characterised as follows:—"Test composed of firmly cemented sand-grains, often with sponge-spicules intermixed, tubular, straight, radiate, branched or irregular, free or adherent, with one, two, or more apertures, rarely segmented."[3] For further comparison see the careful description of Brady.

Judging as to the nature and affinities of these gigantic deep-sea Rhizopods (the majority of which have been recently described), it must not be forgotten that we know very little more than the external form and the structure of their arenaceous shell. The internal organisation, and even the organic contents, of the shells are almost unknown, except in a few cases. On the other hand, the general form of the numerous

[1] Zool. Chall. Exp., pt. xxii. pp. 63, 227, pls. xix.–xxviii.
[2] *Loc. cit.*, p. 63. [3] *Loc. cit.*, p. 64.

genera is so widely different, and partly so insignificant, that they may belong to very different groups.

Arenaceous shells of cylindrical or urceolate form, with a simple mouth-opening at the distal end, occur in very different classes of the animal kingdom, viz.:—1. Foraminifera (Perforata as well as Imperforata); 2. Physemaria (*Prophysema, Gastrophysema*); 3. Spongiæ (Ammoconidæ); 4. Hydroida (*Atractylis, Perigonymus*, &c.); 5. Anthozoa (*Cerianthus*, &c.); 6. Rotatoria (*Melicerta*); 7. Gephyrea; 8. Annelida (Oligochæta and Polychæta); 9. Insecta (larvæ of Phryganidæ, &c.). In all these cases the determination of the group is difficult, or even impossible, when only the shell is known, and not the animal producing it. Sometimes the recognition of the shell is possible by comparison, or by means of secondary circumstances. But in other cases it is quite impossible.

The majority of the gigantic deep-sea Foraminifera described by Brady and others are Imperforata, and possess a solid arenaceous shell; these are therefore not sponges. But a number of arenaceous genera are Perforata, and there may be true sponges among them. It is possible (or even probable) that many arenaceous tubes regarded hitherto as Rhabdamminidæ are indeed Ammoconidæ. Brady himself rightly calls many of his Astrorhizidæ doubtful organisms, of which it is difficult to determine the zoological origin and position. Indeed, his *Sagenella* is so similar to our *Ammoconia*, his *Rhizammina* to our *Ammosolenia*, and his *Rhabdammina* to our *Ammolynthus*, that they may be easily confounded. If we assume that, in the well-known calcareous Asconidæ (*Calcolynthus, Leucosolenia, Auloplegma*), the calcareous spicules are replaced by xenophya (or by foreign skeletal bodies taken from the sea-bottom), we should have the Ammoconidæ figured in Pl. VIII.—*Ammolynthus* (figs. 1, 2), *Ammosolenia* (fig. 3), *Ammoconia* (figs. 4, 5).

Ammoconidæ and Physemaria (*Ammolynthus and Haliphysema*).—A new light is thrown by the Ammoconidæ upon those interesting primitive Metazoa which I described in 1876 as Physemaria (*Haliphysema* and *Gastrophysema*). I had observed two of these organisms in the Mediterranean in the living condition, and bearing eggs (*Haliphysema primordiale* in Corsica, 1875, and *Gastrophysema dithalamium* in Smyrna, 1873). The structures which I found in the walls of these remarkable animals are essentially the same as in the Ammoconidæ collected by the Challenger. The only important difference is that the thin wall of the tubular body is apparently solid and imperforate in the Physemaria, porous and perforate in the Ammoconidæ.

This difference may be explained in two ways. The body-wall of the Physemaria may be indeed imperforate, and in this case they retain the primordial position on the lowermost step of the Metazoa, which I had assigned to them, as "Gastræadæ of the present time." On the other hand, it may be that the body-wall is perforated by numerous microscopical pores, and that these were closed temporarily and accidentally during the

few hours I was examining them; in this case they are Ammoconidæ. I pointed out in my Monograph that the pores of the Asconidæ are often closed for a long time, and when a single tubular *Calcolynthus* (as that of PI. I. fig. 1 in my Monograph) is examined in this temporarily closed state, it may be assumed to be a Physemarium (*Haliphysema*).

The genus *Haliphysema* was first described by Bowerbank (1864) as a simple sponge.[1] Carter afterwards expressed the opinion that it was not a sponge but a Foraminifer,[2] and most of the later writers on the subject agree with him. But I think I have sufficiently demonstrated in my Monograph of the Physemaria[3] that this latter opinion cannot be proved. Bowerbank's original description is so incomplete that his *Haliphysema* may have been either a true sponge (*Ammolynthus*), or a Physemarium (*Prophysema*), or a Foraminiferous Monothalamium (*Rhabdammina*, *Technitella*, &c.). The most careful examination of the original dry specimens (should they still exist) cannot decide this question. It can only be decided by the accurate examination of living or well-preserved specimens from the same locality.

True monothalamous Foraminifera, similar to *Haliphysema*,—and so similar that they appear externally identical,—have been carefully examined in the living state, and described by Möbius[4] in 1874. I myself repeated these observations in 1881 in the coral reefs of Ceylon, where the same forms are very common, and I can completely confirm the correctness of the beautiful figures and accurate descriptions of Möbius. But the striking similarity of the simple tubular organism, described by him as *Haliphysema tumanowiczii*, and of the true Physemaria described by me as *Haliphysema primordiale*, &c.,[5] is merely external. The inner cavity of the first is filled up simply by protoplasma, issuing by the mouth of the tube in the form of numerous branching filaments or pseudopodia. The true gastral cavity of the latter, however, is lined by a flagellated epithelium of the same form as in *Calcolynthus*, and bears amœboid eggs, as in this primordial sponge.

To avoid further confusion, I propose to employ the term *Haliphysema*[6] for that monothalamous Foraminifer in the sense of Möbius, Brady, and most recent authors. For the true Physemaria, however, which I described in 1876 as *Haliphysema primordiale*, *Haliphysema echinoides*, *Haliphysema globigerina*, &c., it will be best to adopt the term *Prophysema*. I may add the remark, however, that this *Prophysema* and the closely-allied *Gastrophysema* may be indeed true Physemaria without pores, as I have described them. But it may be, on the other hand, that true pores really exist in their body-wall, and that they were closed only accidentally during my examination. Should

[1] Bowerbank, Monograph of the British Spongiadæ, vol. i. p. 179, pl. xxx. fig. 359; vol. ii. p. 76; vol. iii. pl. xiii.
[2] *Ann. and Mag. Nat. Hist.*, ser. 4, vol. v. pp. 309 *et seq.*, pls. iv., v., May 1870.
[3] *Jenaische Zeitschr.*, Bd. xi. p. 1, Aug. 1876.
[4] Möbius, Meeresfauna der Insel Mauritius, &c., I. Foraminifera, p. 72, Taf. i.
[5] *Loc. cit.*, Taf. i.–iii.
[6] Norman, The Genus Haliphysema, *Ann. and Mag. Nat. Hist.*, ser. 5, vol. i. pp. 26 *et seq.*, pl. xvi., April 1878.

further observations prove the existence of such pores, then these Physemaria must be united with our *Ammolynthus*, as the simplest forms of Ammoconidæ.

Genus 1. *Ammolynthus*,[1] n. gen.

Definition.—Ammoconidæ with simple, tubular or urceolate, unbranched body. Distal end of the tubule with a simple opening (osculum).

The genus *Ammolynthus* is of special interest, as the simplest of all Keratose sponges, and as a prototype corresponding perfectly to *Calcolynthus* among the calcareous sponges. I propose to retain the term *Olynthus* (first employed in my Monograph of the Calcispongiæ, 1872) for the simplest tubular sponge-type without skeleton, and to use the term *Calcolynthus* for those forms of *Olynthus* which produce calcareous spicules in the mesodermal outer wall of the utricle, and *Ammolynthus* for those forms, the pseudo-skeleton of which is composed of xenophya. The important embryonic stage of many sponges, which corresponds to these mature *Olynthus*-forms, may be called *Olynthula*, and the corresponding hypothetical phylogenetic form—the probable common ancestral form of all sponges—*Archolynthus* (=*Archispongia*).

Two interesting species of *Ammolynthus* were found in the Challenger collection, both representing a simple utricle of the typical *Olynthus*-form. The pseudo-skeleton of the smaller form (*Ammolynthus prototypus*, Pl. VIII. fig. 1) is siliceous, composed of Radiolarian ooze; that of the larger form (*Ammolynthus haliphysema*) is calcareous, composed of Globigerina ooze. The former was better preserved, and exhibited not only remnants of the flagellated entodermal epithelium, but also distinct eggs.

Ammolynthus prototypus, n. sp. (Pl. VIII. figs. 1A–1C).

Habitat.—Central Pacific, Station 271; September 6, 1875; lat. 0° 33′ S., long. 151° 34′ W.; depth, 2425 fathoms; bottom, Globigerina ooze, containing many Radiolarians.

Sponge urn-shaped or urceolate, representing a simple ovate utricle, which is fixed by a slender cylindrical pedicle at the proximal end, and opens by a cylindrical proboscis at the distal end. Pseudo-skeleton composed of siliceous shells of Radiolaria.

Ammolynthus prototypus may be regarded as the simplest architype of a Keratose sponge, corresponding to *Calcolynthus* among the Calcarea.[2] The utricular body has a length of 6 to 10 mm., and in its middle widest portion a breadth of 1 to 1·2 mm. The inferior or proximal half of the body is formed by a cylindrical pedicle 0·3 mm. in diameter, which is fixed to the bottom by a broadened basal plate. The superior or

[1] *Ammolynthus*=Sandy fruit, ἄμμος, ὄλυος.

[2] Compare my Monograph, 1872, pl. i., vol. i., pp. 339, 342, etc.

distal half is ovate, and opens above by a short cylindrical proboscis (caminus). The terminal mouth of the latter, or the osculum (*o*), is simple, circular, and has a diameter of 0·5 mm.

Longitudinal and transverse sections through the utricular sponge (figs. 1A, 1B) show that the internal cavity (or the gastral cavity) is perfectly simple, enclosed by a thin wall of nearly equal thickness (about 0·1 mm.). This cavity opens above by the distal ostium, and in the middle dilated portion by numerous small circular pores, 0·03 to 0·04 mm. in diameter (*p*). The pores seem to be absent in the basal pedicle as well as in the distal proboscis. Probably the sea-water enters into the gastral cavity by these dermal pores and issues by the distal osculum (*o*).

The thin and rather firm wall of the utricle is mainly composed of siliceous Radiolarian tests of those wonderful and most elegant forms making up the Radiolarian ooze of Station 271. They are connected by a granular maltha, or the ground-mass of the connective tissue, which constitutes the outer wall of the sponge. Through this maltha are scattered numerous very small stellate cells, and a few larger amœboid wandering cells (*a*); these are more distinct in the thinner walled proboscis, which is free from xenophya. In some transverse sections (fig. 1B), through the inferior part of the gastral cavity, close to the pedicle, there appear between the xenophya and within the maltha (*m*) single eggs (*e*), naked amœboid cells, 0·1 to 0·2 mm. in diameter. Their nucleus or germinal vesicle (*v*) includes a distinct nucleolus. Further, in some of these sections are visible, on the inside of the wall, small thin bands composed of small granular cells (*n*); these are probably the remnants of the flagellated entodermal epithelium. Fig. 1C shows a small portion of the wall, seen from the inside, in which the above-mentioned structures are more or less distinct.

Ammolynthus haliphysema, n. sp. (Pl. VIII. fig. 2).

Habitat.—Central Pacific, Station 270; September 4, 1875; lat. 2° 34′ N., long. 149° 9′ W.; depth, 2925 fathoms; bottom, Globigerina ooze.

Sponge ovate, with a simple osculum at the distal end, arising from a slender cylindrical pedicle, which is fixed by a broad basal plate. Pseudo-skeleton composed of calcareous shells of Foraminifera.

Ammolynthus haliphysema is closely allied to the preceding species, but differs from it in the simple, not proboscidial, opening of the osculum (*o*), and principally in the composition of the pseudo-skeleton, which is built up of calcareous shells from the Globigerina ooze. The ovate body of the sponge is much larger, 5 to 8 mm. in diameter, and arises from a slender, cylindrical, slightly curved pedicle, which is 10 to 12 mm. long and 1 to 1·2 mm. broad. This is broadened below and attached to the bottom on the proximal

end by an irregular broad basal plate. The mouth-opening—or the osculum (*o*)—on the opposite distal end is circular, 2 mm. in diameter. The total length of the sponge is 15 to 20 mm.

The opaque white body of this species is composed almost entirely of calcareous shells of Foraminifera and their fragments. After being dissolved in dilute hydrochloric acid, there remains a thin membranous wall, pierced by numerous small pores (*p*). These dermal pores are shown in fig. 2 in the complete body, although they are not distinct until the removal of the calcareous matter. On the inside of the thin wall were visible fragments of delicate epithelium, composed of small granular cells; these were, however, not so distinct as in the closely-allied *Ammoconia aulopleyma* (Pl. VIII. fig. 4, *n*).

Genus 2. *Ammosolenia*,[1] n. gen.

Definition.—Ammoconidæ with arborescent body, forming tubular branches, which are not connected by anastomoses. Each branch with a terminal opening (osculum).

The genus *Ammosolenia* is derived from the preceding *Ammolynthus* by branching, and therefore bears the same relation to it as among the Calcarea *Leucosolenia* (or, more strictly speaking, *Soleniscus*) does to *Calcolynthus*. The branched or arborescent body of the tubular sponge bears a number of thin-walled porous branches, and each of these has on the distal end a wide simple mouth-opening. Branched tubes like these are not rare in many deep-sea soundings of the Challenger collection, and are described by Brady in his Report on the Foraminifera (p. 274, pl. xxviii.) under the name of *Rhizammina algæformis*. Their arenaceous pseudo-skeleton is usually composed of Globigerina ooze, as also in our *Ammosolenia rhizammina*. But two important differences separate the latter from the former. The thin wall of the arenaceous sponge (*Ammosolenia*) is pierced by numerous small pores or inhalent openings (fig. 4, *p*), whilst the solid wall of the similar arenaceous Rhizopod (*Rhizammina*) is not perforate. The cavity of the branched tubes is lined in the former by a flagellated epithelium, filled up in the latter by simple sarcode or protoplasm. It must be recorded, however, that this sarcode, as the most important part, in *Rhizammina* as well as in many other large arenaceous Foraminifera, has not been demonstrated by observation, but only assumed theoretically. It may be, therefore, that many of these latter belong to our *Ammoconia* or similar Ammoconidæ.

Ammosolenia rhizammina, n. sp. (Pl. VIII. fig. 3).

Habitat.—Tropical Pacific, Station 216A; February 16, 1875; lat. 2° 56′ N., long. 134° 11′ E.; depth, 2000 fathoms; bottom, Globigerina ooze.

[1] *Ammosolenia* = Arenaceous tubes, ἄμμος, σωλήνιον.

Sponge branched, with free cylindrical branches of equal thickness, each provided at the distal end with an osculum. Pseudo-skeleton composed of Globigerina ooze.

Ammosolenia rhizammina forms dendritic or branched tufts, composed of a variable number of cylindrical, not anastomosing, branches. The small trees have a diameter of 8 to 12 mm., and are either erect or creeping on the bottom of the sea. The diameter of the tubules is between 0·8 and 1·2 mm., the length between 10 and 16 mm. Usually they are of nearly equal thickness, and open at the distal end by a circular mouth. The thin wall of the tubes seems to be solid, and to consist only of *Globigerina* shells cemented together by a scanty maltha. But after removal of the calcareous matter by hydrochloric acid, and staining the residuum by carmine, there remains a thin membrane pierced by numerous small pores. These are disposed in the same manner as in *Ammolynthus haliphysema* (Pl. VIII. fig. 2) and in *Ammoconia auloplegma* (fig. 4). Between the pores are visible here and there small cellular flakes, composed of minute granular cells, perhaps the remnants of the flagello-epithelium. A careful examination of living and well-preserved specimens is, however, required to confirm the sponge-nature of this as well as of the other Ammoconidæ with certainty.

Genus 3. *Ammoconia*,[1] n. gen.

Definition.—Ammoconidæ of reticular shape, forming a network of anastomosing porous tubules, without oscula.

The genus *Ammoconia* among the Keratosa represents the same characteristic form, which is very common among the calcareous Asconidæ, described in my Monograph (1872) as *Auloplegma*. The sponge consists of a network, composed of numerous thin-walled (usually cylindrical) anastomosing tubes. The thin walls are pierced by numerous small round pores, but there is no larger opening or osculum. Whilst the thin outer wall of the tubes in *Auloplegma* is supported by calcareous spicules formed by the sponge itself, in *Ammoconia* it is built up of xenophya, or foreign bodies taken from the sea-bottom. There are two similar species of this genus found on the sea-bottom; in the first (*Ammoconia auloplegma*) the pseudo-skeleton is formed by calcareous Globigerina ooze (Pl. VIII. fig. 4); in the second (*Ammoconia sagenella*) it is sandy and siliceous, composed of sponge spicules and the volcanic debris of the red clay. Very similar to this latter, or even identical with it, may be that form which Brady has figured as *Sagenella frondescens*.[2]

[1] *Ammoconia* = Sandy cement, ἀμμοκονία.

[2] Zool. Chall. Exp., pt. xxii. p. 278, pl. xxviii. figs. 14, 15.

Ammoconia auloplegma, n. sp. (Pl. VIII. fig. 4).

Habitat.—Tropical Atlantic (between the Canary and Cape Verde Islands), Station 89; July 23, 1873; lat. 22° 18′ N., long. 22° 2′ W.; depth, 2400 fathoms; bottom, Globigerina ooze.

Sponge reticular, composed of anastomosing cylindrical branches, the porous wall of which is calcareous, composed of agglutinated *Globigerina* shells.

Ammoconia auloplegma forms a loose roundish network, 12 to 16 mm. in diameter, of the same form as that of the following species, figured in Pl. VIII. fig. 5. The cylindrical branches composing it are, however, only half the size of those of the latter, viz., 0·5 mm. in diameter. They present the same aspect as the free cylindrical tubes of *Ammosolenia rhizammina*, so that the former sponge may be derived from the latter simply by the anastomosing of the branches. The structure of the canal-walls, too, is the same in both. After the removal of the opaque calcareous matter by hydrochloric acid, there remains a delicate membrane, pierced by numerous circular pores (*p*). The membrane contains small stellate cells scattered in a granular maltha (*m*), and a few larger dark granular cells, which may be amœboid wandering cells. Seen from the inside, the porous wall is covered here and there by small irregular flakes of epithelium, composed of minute granular cells, probably the remnants of the flagellated entodermal epithelium (*n*). Fig. 4 on Pl. VIII. is semi-diagrammatic, exhibiting these different elements united as they would appear in a transverse section of the living sponge.

Ammoconia sagenella, n. sp. (Pl. VIII. figs. 5A, 5B).

Habitat.—North Pacific, Station 256; July 21, 1875; lat. 30° 22′ N., long. 154° 56′ W.; depth, 2950 fathoms; bottom, red clay.

Sponge reticular, composed of anastomosing cylindrical branches, the porous wall of which is siliceous, composed of sponge spicules and volcanic debris.

Ammoconia sagenella (in Pl. VIII. fig. 5A magnified four times) forms a loose network, composed of short, cylindrical, anastomosing branches. The diameter of the reticular sponge is 12 to 20 mm., that of the branches 1 to 2 mm., that of the meshes of the network 2 to 4 mm. The thin wall of the tubes is rather hard and firm, pierced by numerous very small circular pores (fig. 5B, *p*). The xenophya composing the wall are siliceous, partly fragments of various sponge spicules, partly small polyhedral or more rounded sand-grains, the characteristic constituents of the red clay (*x*). Some fragments of the tubes, treated with carmine, and seen from the inside, exhibited here and there between the pores small epithelial flakes, composed of small granular cells; they are probably the remnants of the flagellated entodermal epithelium.

Family II. Psamminidæ, Lendenfeld (Pl. VII.).

Definition.—Keratosa without spongin-fibres. Pseudo-skeleton composed of xenophya (or manifold foreign bodies), which are cemented together and enclosed by the transparent maltha. Canal-system vesicular, developed on the Leuconal-type (similar to that of the Spongelidæ).

The family Psamminidæ comprises those Keratosa (or rather "Pseudo-Keratosa") in which no trace of spongin-fibres is developed, the skeleton being composed only of manifold foreign bodies, which are enclosed in the maltha or the mesodermal ground-mass of the connective tissue. Lendenfeld, who founded this family in 1886 (as Psamminæ, a subfamily of the Spongelidæ), gives the following definition of it:—"The skeleton consists of foreign bodies cemented by spongin, which, however, is not distinctly visible; without flesh spicules."[1] Three genera are distinguished by him, *Psammopemma*, *Psammella*, and *Holopsamma*. *Psammella* (Lendenfeld) has not yet been described. The first genus, *Psammopemma*, described by Marshall in 1880, was placed by him in the family Spongelidæ or Dysideidæ. I think, however, that the complete absence of a horny spongin-skeleton is quite sufficient to separate the Psamminidæ from the Spongelidæ. No trace of true spongin or horny substance is to be found either in those species described by Marshall as *Psammopemma* in 1880, nor in those described by Carter as *Holopsamma* in 1885. Both these genera are represented by several new deep-sea forms in the Challenger collection, and it contains besides three new species of a new interesting genus, *Psammina*, the discoidal body of which is remarkable for its simple structure.

The Psamminidæ must be separated from the true Spongelidæ for the same reason as the Halisarcidæ and Chondrosidæ. They are indeed—regarded critically—skeletonless, like the two latter families; for the impregnation of the mesoderm with manifold xenophya, or hard foreign bodies, produces only a pseudo-skeleton,—a solid supporting mass in a physiological sense,—but not to be compared with a true internal skeleton produced by the mesodermal connective tissue itself, as is the case in the Keratosa proper. It would, therefore, perhaps be better to separate the Psamminidæ as "Myxospongiæ arenosæ," or Psammospongiæ, from the true Keratosa, and to unite them with the skeletonless Myxospongiæ (Halisarcidæ and Chondrosidæ).

Dr. N. Poléjaeff, in his Report on the Keratosa,[2] describes two species of *Psammopemma* collected by the Challenger in shallow water. The first is the form illustrated by Marshall (*Psammopemma densum*), dredged at Station 49, in 85 fathoms; the second is a new form (*Psammopemma porosum*)[3] found at Bahia in shallow water. Dr. Poléjaeff gives the following definition of *Psammopemma*:—"Spongelidæ without any

[1] Lendenfeld, Classification of Sponges, *Proc. Zool. Soc. Lond.*, p. 589, Dec. 21, 1886.
[2] Zool. Chall. Exp., pt. xxxi. [3] *Loc. cit.*, pp. 45–50, pl. iii. figs. 3, 4.

differentiated skeletal fibres, the supporting skeleton being represented by foreign enclosures lying separately in the parenchyma, and the secretion of the horny substance having been reduced to the formation of only a thin envelope around the enclosed foreign bodies." In contradiction to this description, the figure of *Psammopemma*, given by Poléjaeff, exhibits no trace of a horny envelope, but the xenophya are imbedded immediately in the maltha or the so-called parenchyma of the mesoderm, in the same way as the flagellated chambers. The same is the case in the original specimens of *Psammopemma densum*, upon which Marshall founded the genus, and which he received from my museum at Jena. A re-examination of them has convinced me that Marshall's description is quite correct, and that there is no trace of spongin in the body, as Poléjaeff supposes. The "horny envelopes" described by the latter are the usual sheaths of xenophya, or the condensed parts of the maltha, which envelop all the foreign bodies in the ground-mass of the connective tissue. But if his *Psammopemma porosum* really possesses "fully-developed horny envelopes around the foreign enclosures, occasionally with very conspicuous outgrowths," then probably this species should be transferred to *Cerelasma* (p. 45), or to an allied genus of Spongelidæ.

The Psamminidæ often seem to inhabit the deep sea, and during the ten years in which I made my investigations on the Challenger Radiolaria, I found in many soundings from the Challenger collection irregularly formed lumps or crusts, which a closer examination proved to be fragments of arenaceous Keratosa without horny fibres. But only seven of these Psamminidæ were preserved in a manner sufficient for their description as new species. In two of these seven deep-sea Psamminidæ the pseudo-skeleton is composed of Radiolarian ooze; in four others of Globigerina ooze; in another it is built up of red clay. It therefore seems probable that all the different kinds of deep-sea bottom are accidentally employed by several Myxospongiæ for the construction of a pseudo-skeleton.

The external appearance of all these Psamminidæ is generally simple and insignificant, the general form being an irregular lump or crust; at first sight one is inclined to regard them as porous lumps of inorganic deposit. But anatomical examination, especially by means of sections through different planes, shows that the sandy body is traversed by branched canals, which are in connection with flagellated chambers, the characteristic organs of sponges.

Canal-System.—The state of preservation of the deep-sea Psamminidæ which I found in the Challenger collection was usually not sufficient to enable one to recognise its true structure with precision; besides, their examination is very difficult, owing to the dense sand masses which fill up the whole mesoderm. In four cases, however, I succeeded in recognising the main parts of the canal-system, and convinced myself that it is constructed on the Leuconal-type. This was recognisable in those four species of Psamminidæ in which the pseudo-skeleton is composed of agglutinated *Globigerina*

shells. Having dissolved the calcareous matter by cautious application of dilute hydrochloric acid, I was able to examine in a rather satisfactory manner the delicate remains, consisting of a scarce, clear maltha, and of the branched canals traversing the latter. The canals have often a distinct *membrana propria*, the wall of which is supported by small xenophya (fig. 7C). Numerous rather large flagellated chambers, of an ovate or oblong form, were visible between the smaller branches of the canal-system, and partly connected with them; here and there, too, the small inhalent canals could be recognised coming from the small dermal pores. The choanocytes were exceedingly small, on an average 0·001 mm. in diameter; the same was observed by Poléjaeff in *Psammopemma porosum*. The best preparation of the canal-system was obtained by vertical sections through the discoidal *Psammina plakina* (Pl. VII. figs. 1C, 1D). In this remarkable preparation were also found single eggs, some in segmentation (figs. 1C, 1D, *e*). Their structure and disposition are similar to those in *Plakina monolopha*.

The excurrent part of the canal-system exhibits in the deep-sea Psamminidæ three different types. The discoidal *Psammina* possesses a girdle of oscula, or of large exhalent openings (usually between ten and twenty) on the peripheral margin of the medal-shaped body (Pl. VII. fig. 2B). The tuberose *Holopsamma* bears either a single osculum on the top of each prominent lobe (fig. 6B, *o*), or a series of oscula (or several series) on the projecting crests of the massive body, between the conical depressions which bear the dermal pores (fig. 7A). The true *Psammopemma* has no distinct oscula at all (figs. 4, 5).

Symbiontes.—The majority of the deep-sea Psamminidæ are not associated with a symbiotic Spongoxenia. Two species only of *Psammina* exhibit this symbiosis, viz., *Psammina globigerina* (Pl. VII. fig. 2C) and *Psammina nummulina* (fig. 3). Between the two parallel hard dermal plates of these discoidal sponges (which in the former are composed of Globigerina ooze, in the latter of Radiolarian ooze) is placed a soft medullar mass, with the canal-system of the sponge, and within this is expanded a network of anastomosing chitinous tubes, filled with dark brown cells (figs. 2C, 3). This is probably the hydrorhiza of a symbiotic Hydroid (*Stylactis?*); its hydranths and gonophores, however, could not be seen.

Genus 4. *Psammina*,[1] n. gen.

Definition.—Psamminidæ with a discoidal body, forming a thin and flat crust or plate, the margin of which is provided with a series of oscula. The canal-system is expanded horizontally in a soft medullar mass, which is enclosed between two hard cortical plates (upper and lower plate), both full of xenophya.

The genus *Psammina*, represented in the Challenger collection by three new and

[1] *Psammina* = Sandy, ψάμμινα.

very interesting species, is characterised by the flat crusty form, representing a roundish or subcircular disc, the peripheral margin of which bears a series of oscula or exhalent openings, whilst the inhalent dermal pores are disposed on the flat upper face of the disc. *Psammina*, therefore, closely approaches in structure those interesting Tetractinellidæ described by F. E. Schulze as Plakinidæ, of which *Plakina monolopha* is a typical form, because of its simple organisation. One of the three new deep-sea forms collected by the Challenger is so similar to it, that it may be regarded as a *Plakina monolopha*, in which the Tetractinellid spicules are lost and replaced by xenophya (calcareous shells of the Globigerina ooze). This species (*Psammina plakina*) contains no symbiotic Hydroid. The two other species are connected with a symbiotic *Spongoxenia* (probably *Stylactis* or an allied genus); its reticular hydrorhiza, composed of brown anastomosing chitinous tubes, is expanded horizontally in the medullar substance of the sponge, between the two solid parallel skeleton plates of the cortical substance (upper and lower face). The pseudo-skeleton in *Psammina globigerina* is composed of Globigerina shells; in *Psammina nummulina* of Radiolarian tests. The canals of the sponge are branched between the meshes of the Hydroid tubes (*h*), and open together with these on the peripheral margin of the disc. The isolated canals exhibit a distinct *membrana propria* (fig. 2D, *c*).

Psammina plakina, n. sp. (Pl. VII. figs. 1A–1D).

Habitat.—South Atlantic, Station 331; March 9, 1876; lat. 37° 47′ S., long. 30° 20′ W.; depth, 1715 fathoms; bottom, Globigerina ooze.

Sponge discoidal, subcircular, composed of two parallel hard cortical plates, with a soft medullar substance between them, the former being composed of *Globigerina* shells, the latter of maltha and a simple gastral cavity, covered by a single layer of flagellated chambers. No symbiotic Spongoxeniæ. Several oscula on the peripheral elevated margin.

Psammina plakina is a very remarkable form, which differs from the following typical species of the genus in such essential points, that it may perhaps be better described as the representative of a new genus, *Psammoplakina discoidea*. Two small specimens were observed forming white subcircular plates, the smaller 5 to 6 mm. in diameter, the larger 10 to 12, and 1·5 to 2·5 mm. in thickness. The internal structure is very similar to that of *Plakina monolopha*, accurately described by Franz Eilhard Schulze. If we were to suppose that the characteristic siliceous spicules of the Tetractinellid *Plakina monolopha* were lost or dissolved and replaced by Globigerina ooze taken from the bottom of the sea, then we should have the structure of *Psammina plakina*.

The consistence of *Psammina plakina* is very hard and solid, not so rigid, however, as in the similar following species. The subcircular disc is slightly convex on the lower,

concave on the upper, side, the peripheral margin being curved somewhat upwards. The convex basal (inferior) face as well as the concave free (superior) face are two parallel thin white plates, composed of small *Globigerina* shells cemented together by a scarce maltha. The medullar or intermediate plate enclosed between these two parallel dermal or cortical plates is somewhat thicker than these, but much softer; it is composed of numerous small shells and fragments of *Globigerina* imbedded in a clear maltha, and of a very remarkable canal-system. The structure of this latter became evident, after having dissolved the calcareous mass of the pseudo-skeleton by hydrochloric acid. Then appeared a flat saccular or pouch-shaped central cavity, divided into irregular chambers by mesodermal septa (figs. 1C, 1D, *g*). From the upper face of this central sac arise numerous lobate diverticles, which are beset with groups of flagello-chambers (*k*). These open by small pores into inhalent canals (*i*), which descend vertically from the upper face. From the periphery of the sac arise numerous excurrent canals, which open into a few peripheral exhalent main canals, and these open free on the peripheral elevated margin by oscula (*o*). About ten or twelve such peripheral oscula could be recognised as larger openings, probably prolonged in the living sponge into prominent oscular tubes or chimneys.

The circulation of the water in *Psammina plakina* is evidently the same as in the similar *Plakina monolopha*, the water entering by the inhalent pores of the concave upper face of the disc, issuing by the exhalent oscula of the margin. Very remarkable is the large simple gastral cavity, or the paragaster (fig. 1C, *g*). This is divided in the following species into numerous chambers, probably due to the development of the symbiotic Spongoxenia (absent in *Psammina plakina*).

In the middle portion of the discoidal body, in that portion of the mesodermal maltha surrounding the basal flagello-chambers, are visible single scattered eggs, some of which are in segmentation (Pl. VII. figs. 1C, 1D, *e*). Although badly preserved, the egg-cells and their large clear nuclei were distinct. Their disposition is also similar to that in *Plakina monolopha*.

Psammina globigerina, n. sp. (Pl. VII. figs. 2A–2D).

Habitat.—Tropical Pacific, Station 220; March 11, 1875; lat. 0° 42′ S., long. 147° 0′ E.; depth, 1100 fathoms; bottom, Globigerina ooze.

Sponge discoidal, subcircular, composed of two parallel hard cortical plates and a soft medullar substance between them, the former being composed almost entirely of *Globigerina* shells, the latter of maltha, with the canal-system and a network of symbiotic Spongoxeniæ. Exhalent oscula on the peripheral margin. Gastral cavity chambered.

Psammina globigerina is very similar to the preceding *Psammina plakina*, and may be perhaps identical with it, but it differs in the more complicated form of the canal-system and the chambered gastral cavity. Perhaps these differences are caused by the development of a reticular symbiont in its interior medullar plate. The irregular roundish or subcircular disc is white, hard, and rigid, between 20 and 30 mm. in diameter, 1·5 to 2·5 mm. in thickness, and is composed of two parallel hard cortical plates, and a soft medullar plate enclosed between them. The two white cortical or dermal plates are composed almost entirely of larger and smaller *Globigerina* shells, cemented together by a scanty clear maltha; the superior plate is pierced by very small pores. The soft medullar mass between the two plates consists of the mesoderm of the sponge with its canal-system, and of the network of a symbiotic Spongoxenia disposed between the branches of the latter. The maltha is filled up with xenophya, fragments of *Globigerina* shells and small complete shells.

Having dissolved the calcareous mass of the pseudo-skeleton by hydrochloric acid, and stained the remains of the body by carmine (Pl. VII. fig. 2D), I could distinguish clearly in the scanty maltha of the mesoderm two branched canal-systems, the dark reticular network of a brown Spongoxenia (probably the hydrorhiza of *Stylactella*, *h*), and the delicate red tree-like tubes of the sponge itself (*c*). The latter are branched, not anastomosing, canals, with a distinct *membrana propria*, and in the course of these the remnants of numerous flagello-chambers. The dark network of the Spongoxenia (or the hydrorhiza), expanded horizontally between the two dermal plates, is composed of anastomosing cylindrical horny tubes, of variable diameter, filled up by greenish brown epithelia. The thickest tubes radiate from the centre of the disc (fig. 2C, *h*).

Psammina nummulina, n. sp. (Pl. VII. fig. 3).

Habitat.—Tropical Pacific, Station 274; September 11, 1875; lat. 7° 25′ S., long. 152° 15′ W.; depth, 2750 fathoms; bottom, Radiolarian ooze.

Sponge discoidal, subcircular, composed of two parallel hard cortical plates and a soft medullar substance between them, the former being composed of Radiolarian tests, the latter of maltha with the canal-system, and the network of a symbiotic Spongoxenia. Gastral cavity chambered. A corona of oscula on the peripheral margin.

Psammina nummulina is, like the two preceding species, a thin and hard subcircular disc (Pl. VII. figs. 1A, 1B), but while the two parallel hard dermal plates of the disc in the two latter are coarsely sandy and calcareous, composed of *Globigerina* shells, they are in *Psammina nummulina* more finely sandy and siliceous, composed of Radiolarian tests. These are cemented together by a rather conspicuous maltha. The upper face of the disc is traversed by numerous small inhalent pores, which are not visible on the lower face.

The exhalent oscula, ten to fifteen in number, are larger, and form a corona on the elevated peripheral margin of the disc (as shown in Pl. VII. fig. 2B). The diameter of the disc is 12 to 15 mm., the thickness 1·12 to 1·18 mm.

The two hard parallel dermal plates of the disc are easily detached from each other, and then is seen between them a softer medullar plate, composed of the branched canal-system of the sponge, and of the network of the symbiotic Spongoxenia (Pl. VII. fig. 3). The structure of the canal-system is difficult to make out, but seems to be similar to that of *Psammina globigerina* (fig. 2D). The inhalent pores on the upper face of the disc open into small canals, and the main tubes of the canal-system open on the elevated margin of the disc by exhalent oscula.

The symbiotic Spongoxenia (fig. 3, *h*) (probably the reticular hydrorhiza of *Stylactis* or an allied tubularian Hydroid) forms an elegant network with polygonal meshes, expanded horizontally in the equatorial plane of the disc between the branches of the canal-system. The anastomosing chitinous tubes of the network are filled by a dark green-brown cellular detritus, sharply defined from the whitish tissue of the sponge.

Genus 5. *Holopsamma*,[1] Carter (1885).

Definition.—Psamminidæ with a massive tuberose or lumpy body, which bears groups of distinct oscula either on prominent ridges or on the top of projecting lobes.

The genus *Holopsamma* was founded in 1885 by Carter with the following definition:—"Arenaceous sponges without fibres, whose composition consists of foreign microscopic objects (sand, fragments of sponge-spicules, &c.) diffused in the flakes of the parenchymatous sarcode, traversed by the canals of the excretory system."[2] Carter points out that "there is absolutely no fibre, but the foreign material is diffused, and so far held together by being imbedded in the delicate flakes of the parenchymatous sarcode" (*i.e.*, the maltha, or the ground-mass of the mesoderm). Carter describes five different species of *Holopsamma;* the three first of these are characterised by a massive lumpy or tuberose body, in which numerous distinct oscula are visible, usually placed on the most projecting parts, either on the margin of crests or the top of lobes. These three typical species of *Holopsamma* are *Holopsamma crassa*, *Holopsamma lævis*, and *Holopsamma laminæfavosa*. To these are closely allied two new deep-sea species obtained by the Challenger, and described in the following pages (*Holopsamma cretaceum* and *Holopsamma argillaceum*). The two remaining species of Carter might be better placed in the genus *Psammopemma* of Marshall.

[1] *Holopsamma* = Whole sand, ὅλος, ψάμμα.

[2] *Loc. cit.*, p. 211.

Holopsamma cretaceum, n. sp. (Pl. VII. figs. 7A–7C).

Habitat.—North Atlantic, Station 70; June 26, 1873; lat. 38° 25′ N., long. 35° 50′ W.; depth, 1675 fathoms; bottom, Globigerina ooze.

Sponge massive, lumpy, forming irregular roundish or bulbous chalk-like masses, composed almost entirely of *Globigerina* shells, cemented together by a scarce maltha. The porous surface exhibits conical depressions; the prominent ridges between them bear series of oscula.

Holopsamma cretaceum is represented in the Challenger collection by a single dry specimen, an irregular tuberose white lump, the diameter of which varies between 20 and 50 mm. The dry sponge is like a piece of common rough chalk, white and very friable. Nearly the whole body is composed of Globigerina ooze, the shells of which are cemented together by a small quantity of maltha. No symbiotic Spongoxenia inhabits this species.

The single specimen of the Challenger collection is figured by Miss Traill from two sides on Pl. VII. figs. 7A, 7B. It is very friable, like chalk, represents an irregular, tuberose, roundish lump, compressed from two sides, and exhibits about a dozen unequal funnel-shaped depressions of the surface. These funnels are 8 to 12 mm. in diameter and are twice as broad as the prominent ridges between them (4 to 6 mm. in diameter). The ridges bear series of black points, which seem to be the oscula of the exhalent canals; they are absent in the white surface of the funnels, in which only the smaller pores of the inhalent canals are to be seen.

After having dissolved the calcareous matter of the skeleton by hydrochloric acid, there remains a very small residuum, composed of the scarce maltha connecting the shells of the Globigerina ooze and groups of branched canals (fig. 7C). These canals have thin structureless walls, and their diameter varies greatly; the smallest branches seem to proceed from the porous thin dermal membrane and are colourless; the canals of medium size bear sand in their walls and exhibit roundish dilatations, which seem to be the remnants of the flagellated chambers. The large canals, which open on the surface by the oscula above mentioned, are easily visible, since their thin wall is impregnated with black pigment-spots; the black oscula have a diameter of 0·4 to 0·6 mm.

Holopsamma argillaceum, n. sp. (Pl. VII. figs. 6A, 6B).

Habitat.—South Pacific, Station 294; November 3, 1875; lat. 39° 22′ S., long. 98° 46′ W.; depth, 2270 fathoms; bottom, red clay.

Sponge massive, lumpy, forming irregular roundish or bulbous masses, composed almost entirely of mineral particles characteristic of the red clay, and cemented

together by a scarce maltha. The porous surface bears conical elevations, and on the top of each cone opens a large osculum.

Holopsamma argillaceum is represented in the Challenger collection by a single small specimen, in the form of an irregular, roundish, tuberose lump, the diameter of which is between 12 and 22 mm. The dry sponge is like a piece of red clay, quite hard and solid, of a reddish grey or light red colour, but it is porous, and transverse sections show the branched canals, proving its sponge-nature (fig. 6B). The smallest inhalent canals open everywhere on the surface by the usual dermal pores; the larger confluent canals open into a few main branches, and each of these opens on the top of a conical protuberance by a large osculum (fig. 6B, *o*). Attempting to isolate the canals from the massive pseudo-skeleton, I was able to discover a few roundish sacs in the course of the smaller canals, apparently the remnants of flagellated chambers. A closer examination of the canal-system, however, was not possible. The fine argillaceous matter, which forms the main-mass of the sponge, is composed of the numerous mineral particles characteristic of the red clay, such as would be produced by the decomposition of felspathic minerals, pumice, and other volcanic products; intermingled are siliceous spicules of different sponges, and their fragments; all these xenophya are cemented together by a small quantity of clear maltha. No Spongo-xeniæ were found in this species.

Genus 6. *Psammopemma*,[1] Marshall (1880).

Definition.—Psamminidæ with an irregular massive or lumpy body, the surface of which is pierced everywhere by small dermal pores, but showing no larger openings or oscula.

The genus *Psammopemma* was founded by Marshall in 1880 upon some Australian sponges preserved in the Museum of Jena. He characterised it by the complete absence of spongin-fibres, the crusty, lumpy, or cake-shaped body being supported by sand or other foreign bodies, connected only by a small quantity of protoplasm. The sandy body is traversed by very narrow branched canals, which exhibit no distinct oscula or larger exhalent openings. This latter character mainly distinguishes *Psammopemma* from *Psammina* and from *Holopsamma*; both these genera possess distinct oscula, as the opening of wide exhalent main canals. The two species of *Psammopemma*, which Poléjaeff describes in his Report on the Keratosa,[2] and which were collected by the Challenger in shallow water, seem to belong to *Cerelasma* (*cf.* below). The author says that "the secretion of the horny substance has been reduced to the formation of

[1] *Psammopemma* = Sandy cake, ψάμμα, πέμμα.

[2] *Loc. cit.*, p. 45.

only a thin envelope around the enclosed foreign bodies." I was not able to discover any trace of true spongin in the different species of *Psammopemma* now described.

This genus seems to be widely distributed in the deep sea, but has been overlooked hitherto, owing to its insignificant shape and usually small size. I have found small fragments belonging to *Psammopemma* in several soundings; they are like irregular lumps or crusts, composed of the sediment covering the sea-bottom. But a closer examination informs us that the apparent sandy concrement is traversed by a branched canal-system, in the course of which are interpolated numerous flagellated chambers.

Psammopemma radiolarium, n. sp. (Pl. VII. figs. 4A, 4B).

Habitat.—Tropical Pacific, Station 272; September 8, 1875; lat. 3° 48′ S., long. 152° 56′ W.; depth, 2600 fathoms; bottom, Radiolarian ooze.

Sponge lumpy, forming irregular, roundish, clavate or turbinate masses, which are composed almost entirely of siliceous Radiolarian tests, cemented together by a scarce maltha. No symbiotic Spongoxenia.

Psammopemma radiolarium, in the characteristic turbinate form, which is represented in Pl. VII. fig. 4A from the side, fig. 4B from below, was found at Station 272; similar specimens occur also in the soundings of Stations 270, 271, and 274, usually in the form of irregular, roundish or cake-shaped, massive lumps, which at first sight were regarded as mere inorganic concrements of Radiolarian ooze. A closer examination, however, principally by means of different sections stained by carmine, informed me that the whole sandy mass of these apparently homogeneous lumps is traversed by an irregularly branched canal-system, opening on the surface by innumerable fine pores. No flagello-chambers nor oscula were visible, but comparison with the similar lumps of the following species makes it very probable that it belongs to this genus. The porous lumps had partly the form of a flat cake or a subglobose mass, partly of a pedunculate club or an inverted cone, sometimes like a peg-top. The diameter of the dry lumps is from 5 to 20 mm. The consistence is that of a soft sandstone or of a friable marl, the colour light grey or whitish. The xenophya of this species are exclusively Radiolarian tests, cemented together by a very scanty maltha; sometimes a few fragments of siliceous sponge spicules are intermingled.

Psammopemma calcareum, n. sp. (Pl. VII. fig. 5).

Habitat.—Tropical Atlantic, between the Canary and Cape Verde Islands, Station 89; July 23, 1873; lat. 22° 18′ N., long. 22° 2′ W.; depth, 2400 fathoms; bottom, Globigerina ooze.

Sponge massive, lumpy, forming irregular, roundish, club-shaped or turbinate masses, which are composed almost entirely of calcareous *Globigerina* shells, cemented together by a scarce maltha. No symbiotic Spongoxenia.

Psammopemma calcareum sometimes assumes, like the preceding species, the characteristic subregular turbinate form, which is figured in Pl. VII. fig. 5, taken from Station 89; the same form has been described in *Holopsamma turbo* by Carter in 1885,[1] but the central depression of the summit of the funnel-shaped body has not the large vent or osculum in its centre, as described in the latter species. The whole surface is coarsely porous, pierced by innumerable smaller and larger pores, but no distinct oscula are visible; they are absent also in the typical species of the genus first described by Marshall. The dry body of our *Psammopemma calcareum* is white, hard, chalk-like, friable, composed almost entirely of smaller and larger *Globigerina* shells, which are cemented together by a scanty clear maltha. After dissolving the calcareous matter in hydrochloric acid, there remains a small residuum, composed mainly of branched canals, similar to those of *Holopsamma cretaceum* (Pl. VII. fig. 7C). The *membrana propria* of the canal-wall is reinforced by small xenophya (sand-grains). The diameter of the specimen figured is between 20 and 25 mm.

Similar pieces of a chalk-like *Psammina* of the same composition occur also at other Challenger stations, where the bottom of the sea is covered with Globigerina ooze, but they have not that regular turbinate form, seen only in the single specimen figured from Station 89. The pieces, which were occasionally observed in the Globigerina ooze of Stations 220, 270, &c., were for the most part roundish or club-shaped, 2 to 8 mm., rarely 12 to 20 mm., in diameter.

Family III. Spongelidæ, Lendenfeld (Pls. IV.–VI.).

Definition.—Keratosa with a reticular horny skeleton, composed of anastomosing spongin-fibres, which enclose xenophya (or manifold foreign bodies). Maltha transparent, not granular, also often supported by xenophya. Canal-system vesicular, developed on the Leuconal-type (similar to *Spongelia*).

The family Spongelidæ (Lendenfeld) or Dysideidæ (Marshall) comprises those Keratosa which produce a network of anastomosing homogenous spongin-fibres and possess a clear maltha, or a transparent, not granular, ground-mass of the mesoderm. They differ in this latter character from the closely-allied Euspongidæ (the Spongidæ of Vosmaer), which all possess a granular maltha (like the Aplysinidæ). Most of the Spongelidæ—especially all the deep-sea forms—are arenaceous sponges or "Psammospongiæ," and possess a pseudo-skeleton composed of manifold xenophya or foreign bodies (sand-grains, calcareous shells of Foraminifera, siliceous shells of Radiolaria and Diatoms,

[1] *Loc. cit.*, p. 213.

spicules of various sponges, &c.). These are disposed in the horny fibres of the skeleton, but sometimes also in the clear maltha or the ground-mass of the mesoderm. Sometimes the spongin is developed very scantily, and forms only thin sheaths, partially covering the xenophya connected by it, or saccular envelopes around them.

The external form in the Spongelidæ is very variable, as also in the Euspongidæ. The canal-system is formed on the Leuconal-type (the third type of Vosmaer), with roundish or oblongish flagellated chambers of variable size, usually rather large, but sometimes very small. It is impossible to retain the relative size of the flagello-chambers as the essential difference between the Spongelidæ and Euspongidæ. Among the Deep-sea Keratosa collected by the Challenger, there are five distinct species belonging to the Spongelidæ. They represent two different new genera, both of special interest. Their peculiar organisation is probably due (to a certain extent at least) to the symbiosis with a Hydroid, the reticular hydrorhiza of which traverses the whole body of these sponges.

The first genus, *Cerelasma* (Pl. VI.), is distinguished from all other Spongelidæ (and probably from all other Keratosa hitherto described) by the peculiar mode of the spongin-secretion. The yellow horny substance of the skeleton forms in the two species of this genus not a framework of anastomosing cylindrical fibres, as usual, but saccular envelopes around the innumerable xenophya which compose the pseudo-skeleton; these are connected by irregular branched lamellæ, which are expanded in the meshes between the branches of the symbiotic hydrorhiza. The sponge itself represents in the two species of *Cerelasma* a globular or tuberose body composed of numerous anastomosing branches, which are either lamellar or cylindrical.

The second genus, *Psammophyllum* (Pls. IV., V.), is represented by three species, which are very similar in external shape to the Stannomid genus *Stannophyllum* (Pls. I., II.). The body is invariably a pedunculated flabelliform leaf. Its spongy substance is supported by the reticular hydrorhiza of a symbiotic Hydroid, and overladen with xenophya. But the essential difference between the two similar genera is, that the simple (rarely branched) spongin-fibrillæ of *Stannophyllum* do not anastomose, form no network, and do not include the xenophya. In *Psammophyllum*, however, as in all true Spongelidæ, the anastomosing spongin-fibres form a network, and include (partially or totally) the foreign bodies of the pseudo-skeleton.

Psammophyllum is closely allied to that remarkable Spongelid described by Esper as *Spongia papyracea*,[1] by Ehlers[2] and Hyatt[3] as *Phyllospongia papyracea*. But if the description of this latter be correct, it differs from *Psammophyllum* in two essential points. The two sides of the flabelliform leaf are the same in *Psammophyllum*, whereas in *Phyllospongia* the upper and lower sides have a very different structure. In the

[1] Esper, Spongien, Forts., Bd. ii. p. 38, Taf. lxv.
[2] Ehlers, Die Esperschen Spongien, pp. 22, 30, 1870.
[3] Hyatt, Revision North Amer. Porif., part ii. p. 73, pl. xvii. fig. 31, 1876.

horny skeleton of the former there is not that distinction between stout primary and delicate secondary fibres as in that of the latter. But one may suppose that the stout spongin-fibres of *Phyllospongia* forming its supporting scaffold have been lost in *Psammophyllum* and replaced by the chitinous tubes of the symbiotic hydrorhiza.

Skeleton.—The marked peculiarity of the five deep-sea Spongelidæ here described, and the principal distinction between them and the well-known Spongelidæ of shallow water, is the complete absence of stout spongin-fibres, forming the firm scaffold of the spongin-skeleton. As already mentioned, these seem to be replaced by the chitinous tubes of the reticular hydrorhiza, produced by the symbiotic Hydroids which traverse the whole body of these curious sponges. The production of the spongin-skeleton, however, is reduced to the scanty and thin fibrillæ or lamellæ which partly enclose the xenophya, partly connect them.

Xenophya.—The foreign enclosures, which fill up the scanty transparent maltha of *Cerelasma* (Pl. VI.) and of *Psammophyllum* (Pls. IV., V.), and which are partly enclosed by the lamellar or fibrous spongin productions, are in three of the five species observed Radiolarian tests, in the other two siliceous sponge spicules intermingled with volcanic mineral particles. The calcareous Globigerina ooze, which composes the pseudo-skeleton in most of the Psamminidæ and Stannomidæ, is rare or entirely absent in these deep-sea Spongelidæ, though the bottom at one Station (216) is true Globigerina ooze. The manner in which the xenophya are collected and disposed seems to prove that in these Spongelidæ (as in the Stannomidæ) there is a power of selection of materials for the construction of the pseudo-skeleton. The scarce transparent maltha, or the ground-mass of the mesoderm, which surrounds and connects the xenophya, contains two kinds of cells: small stellate, fusiform or roundish connective cells, and amœboid wandering cells; the latter probably produce the spongin-skeleton.

Symbiontes.—The firm scaffold of the body in all the deep-sea Spongelidæ is formed not by a network of stout spongin-fibres, as in all the shallow-water inhabitants of this family, but instead by a network of chitinous tubes, which belong to the hydrorhiza of a symbiotic Hydroid. This foreign network traverses all parts of the sponges so densely and continuously (as well in *Cerelasma*, Pl. VI. figs. 2–4, as in *Psammophyllum*, Pls. IV., V.), that in the preliminary examination I was inclined to regard it as an organ-system of the sponge itself, comparing it with the skeletal network of the Aplysinidæ, the branches of which are thin-walled spongin-tubules filled up with a dark medullar mass or pith-substance. But this first supposition was afterwards refuted by the discovery of hydranths, and in some places even of gonangia, being in direct continuity with the chitinous tubes of the network, and filled by the same dark (brown, greenish, or blackish) cellular mass. This mass is evidently the decomposed cœnosarc, the cells of which (entodermal and exodermal) could not be well preserved within the containing dense and decomposing sponge-tissue. The symbiotic

Hydroids belong partly to the Campanulariæ (*Halisiphonia*, Pl. IV. fig. 9), partly to the Tubulariæ (*Stylactella*, Pl. II. figs. 6, 7), partly to a larger Hydroid with annulated tubes, the true position of which I could not make out (*Eudendrium?*, Pl. IV. fig. 4).

Eggs and Larvæ.—Amœboid eggs, with a large clear germinal vesicle and a dark germinal spot (Pl. V. fig. 5, *e*), partly in segmentation, were found scattered in the mesoderm of *Psammophyllum flustraceum* (Pl. IV. fig. 5). The same specimen contained larger dark ovate bodies composed of granular cells, which probably were decomposed or badly-preserved gastrula larvæ, similar in size and form to those of other Spongelidæ.

Genus 7. *Cerelasma*, n. gen.[1]

Definition.—Spongelidæ with reticular spherical or tuberose body, composed of numerous anastomosing branches, each branch supported by a peculiar reticular framework of thin spongin-lamellæ. These, as well as the maltha, enclose numerous xenophya, which are usually enveloped by a spongin-sac.

The genus *Cerelasma* differs from all the Keratosa hitherto described in the peculiar shape of the Keratose skeleton, which is not composed of cylindrical or roundish fibres, but of flat and thin horny lamellæ. These are branched, and the branches unite and form a framework in the most irregular manner. The xenophya possess usually also a saccular envelope of spongin, and are partly enclosed in the maltha, partly in the lamellæ of the framework. This is expanded between the tubular branches of a reticular dark coloured symbion, probably in all cases the hydrorhiza of a symbiotic Hydroid (*Stylactis* or another Spongoxenia).

The peculiar structure of *Cerelasma* may be best understood anatomically, if we compare it with that of a human liver. The reticular system of the hepatic blood-vessels corresponds to that of the symbiotic Spongoxenia, the system of the biliferous canals to that of the canal-system proper of the sponge, the reticular framework of the hepatic glandular cells to that of the maltha full of xenophya, and the supporting framework of the hepatic connective tissue is comparable to that of the Keratose skeletal lamellæ. As in the case of the complex liver structure, the knowledge of the structure of *Cerelasma* is only possible by means of sections through different planes. But the great mass of foreign mineral bodies and siliceous particles crowded in the maltha makes it very difficult to recognise the true structure of this remarkable Spongelid.

The main mass of the body in *Cerelasma* is not formed by the horny framework of the true skeleton, but by the xenophya, which are surrounded by thin horny envelopes, and partly enclosed by the lamellæ. These xenophya or foreign enclosures, which compose the pseudo-skeleton, are in *Cerelasma gyrosphæra* (from Station 271) almost

[1] *Cerelasma*=Horny plate, κέρας, ἔλασμα.

exclusively Radiolarian tests; in *Cerelasma lamellosa* (from Station 216A) partly *Globigerina* shells and their fragments, partly siliceous spicules of sponges and mineral particles. The majority of the xenophya have a peculiar horny envelope, a thin-walled yellow or brown sacculus of spongin. Some of the xenophya (probably those which were most recently incorporated) lie immediately in the transparent maltha, and possess no spongin-envelope. It seems as though the thickness of the sacculi increased with age. The spongin-sacculi are so connected with the branched lamellæ of the skeleton that these latter may be regarded as connecting bands between the former.

The canal-system of *Cerelasma* seems to be similar to that of *Spongelia*, with large flagello-chambers; in the two deep-sea species, however, which I have examined, it was not sufficiently well preserved. In the preliminary examination I was inclined to regard as peculiar canals of the sponge the reticulated canal-system, filled with dark phæodia-like masses, which I afterwards recognised as the hydrorhiza of a symbiotic Hydroid (*Stylactis* or a similar Spongoxenia). The strong chitinous tubes of this latter in *Cerelasma* seem to replace the main spongin-fibres of *Spongelia*.

Probably to this genus belongs also the Keratose sponge which Polejaeff has described as *Psammopemma porosum* in his Report on the Keratosa (p. 48). He says that the foreign enclosures of this species possess a thick envelope of horny substance, "occasionally with very conspicuous outgrowths" (p. 49). The true *Psammopemma* forms no spongin at all.

Cerelasma gyrosphæra, n. sp. (Pl. VI. figs. 1–5).

Habitat.—Tropical Pacific, Station 271; September 6, 1875; lat. 0° 33′ S., long. 151° 34′ W.; depth, 2425 fathoms; bottom, Globigerina ooze, containing a good many well-preserved Radiolarian shells.

Sponge a globular framework, with mæandric surface, composed of numerous cylindrical, anastomosing, convoluted branches. No distinct dermal membrane. Pseudo-skeleton composed almost exclusively of Radiolarian tests.

Exterior.—The body of the single well-preserved specimen is nearly spherical, slightly flattened on the basal side, where it has been attached. The diameter of the globe is between 60 and 70 mm., 66 on an average. The whole surface is similar to that of a gyrencephalon mammalian cerebrum, numerous curved gyri, and between them deep sulci, being turned in all directions. Closer examination shows that this aspect is produced by numerous cylindrical branches, which form a reticular framework by frequent anastomoses. The length of most of the branches is between 6 and 9 mm., the thickness 3 to 4 mm. The sponge, as preserved in spirit, is rather soft and fragile; when dry it is rather hard. The colour is dark brown. The surface of the sponge is rough

and coarsely porous. No distinct dermal membrane is present, whereas in the following species this is easily detached from the softer medulla.

Interior.—The structure seems to be the same in all parts of the sponge. Its main mass is composed of foreign enclosures, viz., the hydrorhiza of a symbiotic Hydroid, and innumerable siliceous shells of Radiolaria, which are embedded as well in the transparent maltha as in the Keratose lamellæ. The latter are expanded in the most irregular manner between the chitinous tubes of the symbiotic Spongoxenia. Between the latter and the former are visible remnants of the canal-system of the sponge, apparently with irregularly-disposed, large, flagellated chambers. The bad state of preservation of the soft tissues, however, did not allow me to form a decided opinion on this difficult subject. (Compare figs. 2–5 and their explanation.)

Spongin-Skeleton.—The true horny skeleton secreted by the sponge itself is composed of two different portions, viz., firstly, the saccular spongin-envelopes which surround the single xenophya, and secondly, the branched lamellæ which connect the former and are expanded in the meshes between the chitinous tubes of the symbiotic hydrorhiza. The thickness of the yellow spongin-plate in the sacculi, as well as in the lamellæ, is very variable, and often much stronger in the nodal points of the network. In those places where the yellow spongin-lamellæ (fig. 3, *f*) are inserted into the outer wall of the similar yellow chitinous tubes of the hydrorhiza (fig. 3, *h*), there is often an appearance as if both these substances might pass directly one into the other; closer examination, however, proves that there is a distinct limit between them (fig. 4).

Xenophya.—The foreign bodies which compose the pseudo-skeleton of *Cerelasma gyrosphæra* are almost exclusively Radiolarian shells, in the astonishing variety and richness which characterises the Radiolarian ooze of Station 271. The majority of these siliceous shells are enclosed by a thinner or thicker envelope of yellow spongin-substance, either an isolated sacculus, or an inflated portion of a lamella (fig. 5, *f*); but there are other xenophya (probably taken up recently) which lie immediately in the clear maltha, without a spongin-envelope.

Symbiontes.—The network of anastomosing cylindrical chitinous tubes, filled by a dark brown cellular mass (figs. 2, 3, *h*), everywhere traverses the body of this sponge so densely, that it occupies perhaps one-third or one-fourth of its volume. In the preliminary examination I was inclined to regard these tubes either as hollow spongin-tubes (similar to those in *Aplysina*) or as peculiar canals of the sponge, but afterwards I was convinced that they belonged to the hydrorhiza of a symbiotic Hydroid, probably *Stylactella*. In some places their epithelium was preserved (fig. 4, *h*).

Cerelasma lamellosa, n. sp. (Pl. VI. figs. 6, 7).

Habitat.—Tropical Pacific, Station 216A; February 16, 1875; lat. 2° 56′ N., long. 134° 11′ E.; depth, 2000 fathoms; bottom, Globigerina ooze.

Sponge an irregular tuberose on subglobose framework, composed of anastomosing lamellar branches. These are covered by a silvery dermal membrane, easily detached from the spongy medullar mass. Pseudo-skeleton composed of different xenophya, principally sponge spicules, *Globigerina* shells, and mineral particles.

Cerelasma lamellosa is represented in the Challenger collection by two tolerably well-preserved specimens, the smaller subglobose, 7 to 9 mm. in diameter, the larger more irregular, tuberose, 16 to 20 mm. in diameter. The coarser and finer structures are the same in both. The body appears to the naked eye as a rather massive framework, composed of irregular lamellar branches, the thickness of which is 1 mm. on an average (the thickest branches 1·5 to 2 mm., the thinner only 0·6 to 0·8 mm.). The lamellar branches are so united as to form an irregular network of inter-canals or of anastomosing tubes, which are invested by the silvery dermal membrane. These curved inter-canals are for the most part cylindrical, with a diameter of 1 to 2 mm., rarely more.

The dry sponge is not elastic, rather firm, but friable. The whole surface and all the inter-canals are silvery, covered by the whitish cortex or dermal membrane, whilst the transverse section of the medullar mass of the lamellar branches is brown, partly yellowish, partly blackish, densely porous (fig. 6). After treatment with carmine the cortex becomes rose, the medulla blackish purple.

Dermal Membrane.—The thin silvery dermal membrane, which covers the whole surface of the anastomosing branches, and also lines all the cavities between them, may be easily detached from the soft brown medullar mass. Its white opaque appearance is produced partly by *Globigerina* shells and their fragments, partly by other xenophya taken from the surrounding ooze, partly by very small roundish mineral particles, which are not soluble in mineral acids. The whole dermal membrane is densely pierced by circular pores, which are very distinct in this species. Between the pores of the sponge are visible larger scattered openings, the external mouths of the tubes of the symbiotic Hydroid.

Medullar Substance.—The brown main mass of the sponge or the porous medullar substance, which remains after the detachment of the white cortex, is composed of the transparent maltha and of a dense network or framework of anastomosing horny lamellæ, both overladen with xenophya, and further of a loose network of the symbiotic Spongoxenia. The structure of the narrow irregular canal-system, and especially the shape of the flagellated chambers, could not be made out in a satisfactory manner, but it seems to be similar to that of *Spongelia*.

Spongin-Skeleton.—The horny lamellæ of the true skeleton are in general thin and broad, of a yellow colour, very irregularly branched, varying greatly in thickness and breadth. They pass over immediately into the horny substance of the saccular envelopes which surround many xenophya. The lamellar branches are everywhere connected by anastomoses, and form a dense framework, the meshes of which are filled up partly by

the canal-system and the maltha, partly by the network of the symbiotic Spongoxenia. The horny lamellæ are partly tubular, partly expanded in the form of thin Keratose membranes. They are overladen with xenophya, in the same way as the granular maltha (fig. 7). There are besides a great number of roundish black-brown pigment-cells scattered in the maltha, so that its structure is difficult to make out.

Xenophya.—The majority of the foreign bodies in the maltha as well as in the Keratose lamellæ are broken siliceous spicules of different sponges; between them are scattered many fragments of *Globigerina* shells and mineral particles, more rarely single tests of Radiolaria. Many xenophya possess peculiar yellow envelopes of spongin, whilst others lie immediately in the transparent maltha (fig. 7).

Symbiontes.—The tubular network of Spongoxenia is very differently developed in the two specimens examined, in one very rich, in the other rather scarce. The anastomosing chitinous tubes are of the same shape as in *Stannophyllum*, and belong probably to *Stylactella;* they are filled with dark cellular detritus.

Genus 8. *Psammophyllum*,[1] n. gen.

Definition.—Spongelidæ with foliaceous or flabellate body, supported by a network of homogeneous spongin-fibres of nearly equal thickness, which enclose manifold xenophya. Maltha clear, also often filled by xenophya.

The genus *Psammophyllum*, represented in the Challenger collection by three deep-sea species, is in the external foliaceous form very similar to the Stannomid *Stannophyllum;* in internal structure it is closely allied to the typical *Spongelia* or *Dysidea*. It differs from this latter in the flat leaf-like form of the body, which seems to be partly produced by the flabelliform growth of the symbiotic Hydroids (*Stylactella*, *Halisiphonia*, &c.) (*cf.* below). On the other hand, *Psammophyllum* seems to be nearly allied to *Phyllospongia papyracea*, Ehlers; from this, however, it differs essentially in the absence of main-fibres and the structure of the skeleton (*cf.* above, p. 43).

The three species of *Psammophyllum*, which are described in the following pages, were taken in the Tropical and Northern Pacific (from depths between 2100 and 2900 fathoms), and are of special importance; they are very similar in external shape, but rather different in internal structure. *Psammophyllum annectens* (Pl. IV. figs. 1–4) is very similar to *Stannophyllum zonarium*, and has similar thin spongin-fibrillæ, but they exhibit frequent ramifications and anastomoses, and begin to enclose xenophya. *Psammophyllum flustraceum* (Pl. IV. figs. 5–9) is distinguished by much coarser spongin-fibres, of very unequal thickness, many enclosing xenophya, as in *Spongelia*. It approaches more to *Psammophyllum reticulatum*, in which the horny network is composed of scanty fine

[1] *Psammophyllum* = Sandy leaf, ψάμμα, φύλλον.

fibres, which partly connect, partly include, the xenophya. These foreign bodies are in the latter species principally siliceous spicules of different sponges; in the first species principally Radiolarian tests, and in the second species both these forms of xenophya are found. The chitinous tubes of the hydrorhiza of the symbiotic Hydroids replace in all the three species the stout main fibres which are characteristic of *Spongelia*.

Psammophyllum reticulatum, n. sp. (Pl. V. figs. 1–4).

Habitat.—Tropical Pacific, Station 198; October 20, 1874; lat. 2° 55′ N., long. 124° 53′ E.; depth, 2150 fathoms; bottom, blue mud.

Sponge foliaceous, reniform, pedunculate, very thin, felty, with undulate distal margin. Surface reticulate, without concentric zones. Framework of the spongin-fibres very scanty and loose, mainly composed of very thin and solid anastomosing fibres, which connect siliceous spicules of different sponges and other xenophya. The same foreign spicules also fill up the maltha.

Psammophyllum reticulatum has the shape of a broad reniform leaf, which attains, in the largest specimen preserved, a height of 50 to 60 mm. and a breadth of 80 to 90 mm. or more. The majority of the specimens preserved are about half that size or less; there are a few small leaves in the collection, which are only 3 to 4 mm. in height and 5 to 6 mm. in breadth, but the form and structure is the same as in the largest leaves. The thickness of the leaf is between 1 and 5 mm., usually 2 or 3 mm., and nearly equal throughout the whole extent, but several leaves are thinner in the middle part (only 0·4 to 0·5 mm.) and thicker on the club-shaped base of the pedicle (7 or 8 mm.). The pedicle is cylindrical, usually about half as long as the leaf itself, gradually broadening toward both ends; the basal end is thickened and expanded into an irregular foot-plate for attachment.

The colour of the leaves is brown, the consistence very soft and fragile, little elastic. The entire surface is felty or woolly, and the aspect of the body at first sight is that of a thin felt-sole or hair-sole. It is very loose in texture and easily torn to pieces. The woolly aspect and the felty consistence of the surface is produced by the numerous large spicules of siliceous sponges everywhere prominent and matted together.

Symbiontes.—The characteristic reniform leaf-shape of the sponge is evidently produced by the dense network of the symbiotic Hydropolyp (Spongoxenia), which is growing in a vertical plane, like a *Rhipidogorgia*. The sponge itself is only a thin woolly mantle, which covers both sides of the foliaceous polyp-corm and fills up the meshes of its loose network. The chitinous tubes of this latter are cylindrical, often varicose, 0·1 to 0·2 mm. broad; the meshes between them are 1 to 3 mm. in diameter. The tubes are irregularly curved, broadened on the nodal points of the network, and

contain the usual brown phæodia-like contents, which fill up the hydrorhiza of the symbiotic Tubularian (probably *Stylactis* or *Stylactella*, figs. 2, 3, *h*). I was, however, not able to observe anywhere the hydranths or the gonophores of the Hydroid, which might be due to the bad state of preservation.

Xenophya.—The foreign bodies which compose the pseudo-skeleton of this species are almost exclusively various siliceous spicules of sponges, belonging to very different genera of Hexactinellida, Tetractinellida, and Monaxonida; the quality and quantity of different forms is very variable, according to the accidental composition of the ground on which the sponge grows. The majority of the xenophya, and especially the larger spicules, are not completely enclosed by the horny fibres, but only partially on the ends.

Horny Skeleton (figs. 2–4, *f*).—The entire body of the foliaceous sponge is supported and traversed by a very fine framework, composed of anastomosing horny fibres produced by the sponge itself. Examined by a weak lens, this delicate network fills up all the meshes of the coarser network of the polyp-corm (fig. 1). The yellow horny fibres are of the usual Keratose structure, the broader with a distinct axial filament. The majority of the fibres are 0·004 to 0·006 mm. broad, many finer, only 0·001 mm. or less; rarely there are larger fibres, 0·01 to 0·012 mm. in diameter, or even more. The stellate nodal points of the Keratose network are 0·02 to 0·04 in diameter.

Psammophyllum flustraceum, n. sp. (Pl. IV. figs. 5–8; Pl. V. fig. 5).

Habitat.—North Pacific, Station 241; June 23, 1875; lat. 35° 41′ N., long. 157° 42′ E.; depth, 2300 fathoms; bottom, red clay.

Sponge foliaceous, reniform, pedunculate, rather thick and soft, with lobulate distal margin. Surface with branched ribs in the proximal part, with concentric zones in the distal part. Framework of the spongin-fibres very dense and irregular, composed of branched and anastomosing fibres of unequal thickness; these include numerous siliceous spicules of sponges, Radiolarian tests and other xenophya, which also fill up the maltha.

Psammophyllum flustraceum is of special interest as a connecting link between the preceding and the following species. The single specimen observed (figured in Pl. IV. fig. 5, natural size) is a broad flabelliform leaf, similar to *Stannophyllum venosum* (Pl. I. fig. 4). Its breadth is 105 mm., its height (without pedicle) 70 mm.; the slender pedicle, which arises from the centre of the concave proximal margin, is inversely conical, 33 mm. long, 16 mm. broad at the distal insertion. The convex distal margin of the leaf is lobulate, with twelve to fifteen large lobes, each of which is again divided into two to four smaller lobules.

The surface of the reniform leaf is felty, of a brown colour. The proximal part is traversed by branched radiating ribs, which diverge from the attachment of the pedicle,

similarly as in *Stannophyllum venosum* (Pl. I. fig. 4). The ribs are lighter in colour, grey or whitish; they disappear in the distal part of the leaf, which exhibits distinct concentric zones of nearly equal breadth (3 to 4 mm.). The zones are more prominent than in the following species, and more thickened in the proximal part, so that the vertical section is cuneiform (Pl. IV. figs. 7, 8). Each zone therefore covers with its thickened proximal edge the thinner distal part of the neighbouring proximal zone; the thickened edge exhibits an irregular row of large openings, probably the oscula (fig. 7, *o*), whilst the felty dermal membrane of the surface is pierced by the smaller dermal pores (fig. 7, *p*). The outermost distal zones exhibit oscula also on the two faces (fig. 8, *o*). Scattered in some parts of the mesoderm were found amœboid egg-cells, similar to those of other Keratosa (Pl. V. fig. 5, *e*).

Symbiontes.—The spongy parenchyma between the two parallel dermal plates is traversed by numerous anastomosing cylindrical tubes, which form a rather dense network. These chitinous tubes belong to the hydrorhiza of a symbiotic Hydroid, *Halisiphonia spongicola* (Pl. IV. fig. 9). After long continued researches, I was successful in finding in some portions of the sponge the club-shaped gonangia (fig. 9, *g*) as well as the urn-shaped hydrothecæ (fig. 9, *p*) of the symbiotic Spongoxenia. The cellular contents of the chitinous tubes were rarely distinct (Pl. V., fig. 5, *h*); usually they were destroyed, their remains forming a dark granular mass of an olive or brown colour.

Xenophya.—The foreign bodies which compose the pseudo-skeleton in this species are more varied than in the preceding and following species. Siliceous spicules of sponges, tests of Radiolaria, and various mineral particles characteristic of the red clay, occur intermingled. They are partly crowded in the clear maltha, partly enclosed by the meshes of the network of the spongin-fibrillæ (Pl. IV. fig. 6, *r*), and the smaller xenophya are enclosed in the horny fibres, as in *Spongelia*.

Horny Skeleton.—The spongin-fibres in this species are more developed than in any other Deep-sea Keratosa here described. They form a dense irregular network, exhibit numerous ramifications and anastomoses, and are of very unequal thickness (Pl. IV. fig. 6, *f*). The thinner fibrillæ (0·001 to 0·01 mm. in diameter) are equal to those of *Stannophyllum*, whilst the thickest fibres (0·02 to 0·06 mm.) approach those of *Spongelia*. The axial thread is very distinct.

Psammophyllum annectens, n. sp. (Pl. IV. figs. 1–4).

Habitat.—North Pacific, Station 244; June 28, 1875; lat. 35° 22′ N., long. 169° 53′ E.; depth, 2900 fathoms; bottom, red clay.

Sponge foliaceous, reniform, pedunculate, rather compact and elastic. Surface with concentric zones of equal breadth. Framework of spongin-fibres very irregular,

rather dense, composed of branched fibres of nearly equal thickness; the majority of the fibres without xenophya; the thickest fibres enclose remains of Radiolaria, which also fill up the maltha.

Psammophyllum annectens has the same external appearance as *Stannophyllum zonarium* (Pl. I. fig. 1); it is a broad reniform leaf, soft and thin, of a brown colour with concentric zones on the surface. The height of the leaf (without pedicle) is usually 25 to 30 mm., breadth 35 to 40 mm., thickness 1 to 3 mm. The largest specimen, however (figured in Pl. IV. fig. 1), is 75 mm. broad, 55 mm. high, without the pedicle (10 mm.). The concentric zones or bands of both surfaces, which run parallel to the semicircular margin, have the same breadth as in the similar *Stannophyllum zonarium*, 3 to 4 mm.; they are separated by superficial furrows, somewhat thicker on the proximal than on the distal margin. The dried body is very soft and flexible, of felty appearance. The inferior edge of the kidney-shaped leaf is more or less concave (in a smaller specimen scarcely emarginated), and from its centre starts a short conical pedicle, with a small basal plate for attachment.

Canal-System.—The entire surface of the sponge on both sides of the leaf is covered by a rather firm dermal membrane, and this is pierced by small inhalent pores; between them are scattered at irregular distances larger openings (two or three times the diameter of the inhalent pores), probably the exhalent oscula; these occur mainly on the proximal margin of the concentric zones, which is somewhat thickened. The large subdermal cavities, which occur in the similar *Stannophyllum*, are absent in this species.

Symbiontes.—The whole spongy parenchyma of the leaf between the two dermal plates is traversed by a network of cylindrical anastomosing tubes, the hydrorhiza of a symbiotic Hydroid (Spongoxenia). Perhaps this is the same, *Stylactella abyssicola*, as occurs in the similar *Stannophyllum*. I was able to find in one specimen the hydranths and gonophores, which were not distinct in the latter (*cf.* Pl. II. fig. 7).

Xenophya.—The foreign bodies which compose the pseudo-skeleton in this species are almost exclusively siliceous shells of numerous Radiolaria and their fragments, as in the closely-allied species of *Stannophyllum* (*radiolarium* and *zonarium*). They fill up the clear maltha of the mesoderm, and are connected, and partly enclosed, by the spongin-fibrillæ (Pl. IV. figs. 2, 3, *f*).

Horny Skeleton.—The spongin-fibrillæ in this species are more like those of *Stannophyllum* and those of the Stannomidæ in general than in any other Spongelidæ hitherto known. They are very thin and of nearly equal breadth (0·003 to 0·006 mm. on an average), but they differ from the simple fibrillæ of the Stannomidæ in the numerous ramifications and anastomoses. The network thus formed includes the xenophya, and the larger Radiolarian shells are surrounded by its meshes. Smaller shells and fragments are also enclosed in the fibres, and they fill up the maltha between them (Pl. IV. fig. 2, *r*). *Psammophyllum annectens*, therefore, is a true intermediate form

between *Stannophyllum* and the other species of *Psammophyllum*, which in structure approach more to *Spongelia*.

Family IV. Stannomidæ, n. fam. (Pls. I.-III.).

Definition.—Keratosa with a fibrillar spongin-skeleton composed of thin, simple or branched, spongin-fibrillæ, never anastomosing or reticulated. Pseudo-skeleton composed of xenophya (or diverse foreign bodies), which are crowded in the transparent maltha, never in the homogeneous fibrillæ. Canal-system vesicular, developed on the Leuconal-type (similar to that of the Spongelidæ).

The new and most remarkable family Stannomidæ comprises those Keratosa hitherto unknown, which produce true horny fibrillæ in the mesoderm, and besides possess a pseudo-skeleton composed of various xenophya; but these foreign bodies are enclosed in the clear maltha or the ground-mass of the connective tissue, not in the spongin-fibres (as in the Spongelidæ). All Stannomidæ are inhabitants of the deep sea; they are very dissimilar in external form, while they all agree in internal structure. Three different types of external form may be distinguished, viz.—(1) *Stannophyllum*, with foliaceous or laminar flabellate body (Pls. I., II.); (2) *Stannarium*, with a branched body, composed of several free or coalescent foliaceous wings (Pl. III. figs. 6–14); and (3) *Stannoma*, with a branched arborescent or coralliform body, the branches of which are cylindrical, either free or connected by anastomoses (Pl. III. figs. 1–5). The size of these two latter Stannomidæ is usually between 30 and 60 mm., while the large flabelliform leafs of *Stannophyllum* reach a diameter of 100 to 200 mm. and more.

The Stannomidæ discovered by the Challenger have all been found in the central part of the Tropical Pacific, in depths between 2425 and 2925 fathoms. The majority of the specimens collected were taken at Station 271, in the equatorial central Pacific (depth, 2425 fathoms); some other forms were captured in the neighbouring Stations 270 and 272. The Stannomidæ are the most important and most interesting of all the Keratosa collected by the Challenger. Their structure is so strange and so peculiar that several distinguished spongiologists, to whom they were submitted for investigation, said they were not sponges. Some naturalists declared that they were gigantic Rhizopods. Nevertheless I am now quite convinced that they are true horny sponges; some new forms of *Psammophyllum* (Pls. IV., V.), which form an uninterrupted continuous series of modifications and connecting links between *Stannophyllum* and *Spongelia* (*Phyllospongia*), leave no room for doubt.

Unfortunately, the state of preservation of all the Stannomidæ collected, as well as of the peculiar Hydroida living in symbiosis with them, was very imperfect, and not sufficient for the examination of the finer structures. It is natural that "these delicate things, drawn up rapidly through the water from a depth of nearly four statute miles,

and transported into such totally different conditions of temperature, pressure, &c., suffer greatly from this violent change. They are, in fact, almost knocked to pieces, and their fine tissues are in a nearly deliquescent state." This is what Sir Wyville Thomson says, when speaking of the gigantic Hydroid *Monocaulus*, and the same may be said of the Stannomidæ and their delicate symbiotic Hydroids.[1]

Indeed it was quite impossible, in spite of all possible precautions and different methods of examination, to make out the anatomical structure of the canal-system of the Stannomidæ, and especially of the flagello-chambers. The dermal membrane, too, was more or less destroyed. It is very probable that they agree in these particulars with the closely-allied Spongelidæ, with which they are closely connected by intermediate forms (*Psammophyllum*). Nevertheless the composition of the well-preserved skeleton, and the relations with the symbiotic Hydroids, are so peculiar, that they are sufficient for the erection of a new family.

Skeleton.—Accepting the term "skeleton" in the usual physiological sense as the combination of all the solid parts of the body which serve as supporting and protecting organs, due to their hard and firm consistence, we may say that the skeleton of the Stannomidæ consists of three different parts, viz.—(1) the delicate spongin-fibrillæ produced by the sponge itself; (2) the xenophya, or the foreign enclosures (siliceous shells of Radiolaria, calcareous shells of Foraminifera, &c.), all received from the ooze of the sea-bottom; (3) the chitinous tubes of the hydrorhiza of the symbiotic Hydroids, which replace the absent stout spongin-fibres. The two latter elements, of course, represent a pseudo-skeleton composed of foreign enclosures, whilst the first alone is the true skeleton proper of the sponge. But the most curious fact is, that in all these Stannomidæ the main mass of the body consists of the pseudo-skeleton, and that the fibres of the spongin-skeleton form only a delicate connective tissue between the constituents of the pseudo-skeleton. The spongin-fibrillæ appear as a framework of fine elastic threads (*f*) strengthening the scanty maltha, which holds together all the different parts of the sponge. (Pl. II. figs. 1–3, *m*).

Maltha.—The ground-mass of the mesoderm, which we briefly call maltha (the mesoglœa, mesenchyma, collenchyma, intercellular substance, common ground-mass, &c., of other authors), is in all the Stannomidæ scanty, and appears as a soft (clear and transparent) structureless mass, cementing all the heterogeneous parts of the sponge and its foreign enclosures together. The maltha has the same characters as in the closely-allied Spongelidæ; it is clear and transparent, not granular, and contains two different kinds of connective cells—(1) malthar cells, the usual small cells of the connective tissue, roundish, spindle-shaped or stellate, with scanty protoplasm around the small nucleus; and (2) amœboid wandering cells, probably migrating slowly through the whole body and producing the fibrillæ (similar to the odontoblasts which produce the dentin-fibrillæ).

[1] Compare Zool. Chall. Exp., part lxx. p. 6.

Spongin-Fibrillæ.—The fibrillæ characteristic of the Stannomidæ are imbedded in the clear hyaline maltha or the connective ground-mass, and exhibit the same physical and chemical peculiarities as the well-known corneous fibres of the common Keratosa; they consist, therefore, of spongin (or spongiolin). Usually they are simple cylindrical filaments, rarely a little branched, never anastomosing or reticular. Their colour is yellow, sometimes light brownish (Pl. II. figs. 1–3, *f*; Pl. III. fig. 9).

Size of the Fibrillæ.—The fibrillæ are in general very long, but difficult to determine, since it is usually impossible to isolate them for their whole length; in some macerated specimens, however, I was able to separate fibrillæ 2 to 5 mm. in length, and in one case even a thread 11 mm. in length. I suppose that they often really attain a length of some centimetres or more; perhaps often (or even constantly?) a great part of the fibrillæ run uninterruptedly from the base of the sponge to its periphery. Their thickness is usually equal throughout their whole length, viz., 0·001 to 0·004 mm. on an average, but sometimes the thicker fibrillæ attain a diameter of 0·01 to 0·02 mm., whilst the thinnest threads are only 0·0001 to 0·0005, or even less. In the majority of the Stannomidæ the thickness of the fibrillæ varies very little, and is nearly constant in one and the same specimen.

Arrangement of the Fibrillæ.—The arrangement of the spongin-fibrillæ in the body of the Stannomidæ is rather variable, and seems to depend often upon the mode of growth and the development of the pseudo-skeleton and of the symbiotic Hydroids. Often all the fibrillæ run isolated, irregularly interwoven in all directions. But usually the fibrillæ are aggregated densely in bundles, connected by a minimum quantity of maltha. The smaller bundles are composed of four to eight, the larger of ten to twenty or more parallel fibrillæ. When the bundles branch, a part of the unbranched fibrillæ separates from the rest and passes into the branch, similar to the nervous primitive fibres in a branching nerve. The fibrillæ themselves do not usually branch, but in some of the Stannomidæ, and especially in those in which the pseudo-skeleton is composed of Globigerina ooze, the thicker fibrillæ branch frequently. The branches are sometimes of equal, at other times of unequal, thickness; they never anastomose in the true Stannomidæ. As soon as the neighbouring branched fibrillæ anastomose and form a network, the Stannomidæ pass over into Spongelidæ. So *Stannophyllum* (from Station 271) passes over into *Psammophyllum* (Stations 241 and 244).

Structure of the Fibrillæ.—The thinnest fibrillæ appear under the microscope, even with the highest powers, perfectly structureless; but in the thicker threads, mainly the thickest forms (0·01 to 0·02 mm. in diameter), may be clearly distinguished a central medullary substance or an axial thread and a peripheral cortical substance; the latter is usually also in the thickest threads much broader than the former, but in some of the Stannomidæ distinguished by rather thick fibrillæ the axial thread is twice as broad as the surrounding cortical tube. In some macerated specimens the axial canal

of the dry fibrillæ was filled with air. The difference between the thin axial thread and its thick spongin-envelope is the same as in the thinner forms of the so-called homogeneous horny fibres of the Euspongidæ, Spongelidæ, &c. On the other hand, they recall also the peculiar so-called "filaments" of the Hircinidæ, and this leads us to the question of the true nature of the fibrillæ.

Nature of the Fibrillæ.—The first question arising out of the examination of the peculiar fibrillæ of Stannomidæ, and also of the similar "filaments" of the Hircinidæ, is this: Are they produced by the sponge itself? or are they foreign organisms which live in the sponge as parasites or symbiontes? As is well known, this question is not yet decided in the case of the Hircinidæ. Poléjaeff, in his Report on the Keratosa,[1] discusses the nature and the systematic value of the filaments of the Hircinidæ, and the majority of modern spongiologists agree with him when he says that "their nature as independent organisms is clearly established." But of what nature are these "independent organisms?" No zoologist will accept them as animals, no protistologist can regard them as neutral protists, no botanist will acknowledge their vegetable nature! All botanists who have thoroughly examined the filaments of the Hircinidæ, and among these are some great authorities, mainly fungologists, declare decidedly that they are not fungi, and not plants at all. Indeed, neither their chemical nature nor their anatomical structure is that of any fungus or alga, and, although many observers have examined them for a long time and in all possible directions, no one has been able to discover their fructification and development.

Poléjaeff's principal argument in favour of the parasitical nature of the filaments found in the Hircinidæ is as follows:—"F. E. Schulze made out the structure of sponges characterised by the presence of filaments, and found that anatomically and histologically they do not differ from sponges which, like *Euspongia*, have never been found with filaments."[2] This argument, in my opinion, has no decisive value. If we apply it to the Chondrosidæ, we might arrive at the following conclusion:—"*Chondrilla*, characterised by the presence of sphero-stellate siliceous spicules, does not differ anatomically and histologically from *Chondrosia*, which has never been found with these spicules. Therefore these spicules are not produced by the sponge itself, but are independent organisms." On the other hand, the fact that the fibrillæ of the Hircinidæ are not in direct connection with the reticulate horny skeleton of these Keratosa has also no decisive value. For *Darwinella* possesses numerous radiate horny spicules imbedded in the mesoderm, without connection with the ramified tree of the Keratose skeleton; so also have many Halichondrinæ siliceous "flesh-spicules" imbedded in the connective tissue, without connection with the main skeleton.

I am therefore inclined to regard the filaments of the Hircinidæ, and also the similar fibrillæ of the Stannomidæ, as true skeletal fibres, comparable to the elastic fibres in the

[1] Zool. Chall. Exp., part xxxi. pp. 11–16.

[2] *Loc. cit.*, p. 13.

connective tissue of many animals. They may be developed to strengthen the soft ground-mass of the mesoderm, independently from the primary Keratose skeleton. The fibrillæ of the Hircinidæ, ending at the two free ends with a club or knob, may be regarded as monaxial Keratose spicules, similar to the siliceous "biclavated cylindrical spicula" of Bowerbank. They strengthen the tissue of the Hircinidæ in the same manner as the elastic fibrillæ in many kinds of connective tissue.

The fibrillæ of the Stannomidæ seem to be more nearly related, physically as well as chemically, to the common horny fibres of the Keratosa than to the similar filaments of the Hircinidæ. No single fact in their structure, arrangement, and development makes it probable that they are independent organisms. Several botanists who have examined them, and among them two fungological authorities, declared decisively that they are neither fungi nor algæ. I am therefore fully convinced that they are produced by the sponge itself.

Xenophya.—The solid foreign bodies which form the pseudo-skeleton and make up the greatest portion of the body of the Stannomidæ are either siliceous Radiolarian shells, or calcareous *Globigerina* shells, or a combination of both materials. The pseudo-skeleton is composed of pure Radiolarian ooze in five among the nine species, of pure Globigerina ooze in two, and of a mixture of both in the other two species. The two latter species (*Stannophyllum pertusum* and *venosum*) are most remarkable, since several parts of the body (the strong ribs of the leaf) are mainly composed of the coarser Globigerina ooze, whereas other parts (the intercostal plates) are composed of the finer Radiolarian ooze. This fact, as well as others observed in the Psamminidæ and Spongelidæ, seem to uphold my opinion (stated in my description of the Physemaria) that these animals possess a faculty of selection of materials in the construction of their pseudo-skeleton. This opinion is supported, too, by Lendenfeld and Carter (1885), but it is attacked by F. E. Schulze, Marshall, Poléjaeff, and others.

The xenophya are placed so densely and close together in all the Stannomidæ that the connecting maltha appears only as a scarce cement between them. They are never enclosed in the spongin-fibrillæ, but these run everywhere between the foreign enclosures, either single or associated in bundles (Pl. III. figs. 2–4, &c.). When the dermal plate of the sponge is well developed, the crossed bundles of fibrillæ form subregular meshes, in which groups of xenophya are placed, and the dermal pores are scattered at varying distances (Pl. II. figs. 1–4, &c.).

Symbiontes.—Whilst the protecting sandy carapace of the Stannomidæ is formed by the agglutinated xenophya, the supporting scaffold, which gives stiffness and solidity to the body when erect, is formed by a dense network of anastomosing chitinous tubes, filled with a dark brown or blackish cellular mass. In the preliminary examination I supposed that this constant network might be a constituent portion of the sponge itself, a tubular skeleton similar to that of the Aplysinidæ, composed of thin-walled heterogeneous fibres,

which contain a soft medullar or pith-substance. But a closer examination of the different Stannomidæ, and a comparison with the Spongelidæ and Psamminidæ, have convinced me that the network is the hydrorhiza of a symbiotic Hydroid; this conjecture was finally proved by the discovery of the hydranths and gonangia (figured in Pl. II. figs. 6, 7, &c.; see their description in the Appendix). I suppose that these strong chitinous tubes of *Stylactis*, &c., replace the absent stout spongin-fibres of the skeleton in the Stannomidæ, and that the want of these latter may be supplied by the development of this curious symbiosis. The same remarkable condition is found among the Spongelidæ, in *Psammophyllum* (Pls. IV., V.), which connects this family with the Stannomidæ.

Canal-System.—The Stannomidæ seem to agree in the essential structure of the canal-system with the closely-allied Spongelidæ, with which they are immediately connected by the transitional genus *Psammophyllum* (Pls. IV., V.). Below the porous dermal membrane, which is very distinct in *Stannophyllum* and *Stannarium*, there are usually large subdermal cavities. These communicate with the internal canal-system, which is expanded, together with the symbiotic hydrorhiza, between the two parallel dermal plates of these foliaceous sponges. In *Stannoma*, where no distinct dermal membrane was preserved, the canals in the cylindrical branches form a closer network, with smaller meshes. The form, size, and disposition of the flagellated chambers seem to be similar to those of the Spongelidæ, but only traces of them could be found; their epithelia were destroyed in the same way as the exodermal epithelium of the outer surface.

Eggs and Gastrulæ.—Having convinced myself that the Stannomidæ are true sponges (and not "gigantic Rhizopods," as was supposed by the first observers), it was, of course, very important to confirm that opinion by the authentic demonstration of eggs, and if possible gastrulæ. For a long time I looked in vain for them, but at last I was fortunate enough to find them in a single specimen of *Stannophyllum globigerinum*, apparently better preserved than the others. After having stained it with carmine and dissolved the calcareous pseudo-skeleton in hydrochloric acid, I found scattered here and there in the maltha single amœboid cells with a large vesicular transparent nucleus and a dark nucleolus. The largest were so similar to the usual naked sponge eggs (especially to those of *Psammophyllum*, Pl. V. fig. 5, *e*, and of *Spongelia*), that I had no doubt as to their egg nature, the more so as a few eggs were found in segmentation. Finally, some larger dark ovate bodies, composed of granular cells which were found in the same specimen, may be its gastrula larvæ; they were, however, not sufficiently well preserved to allow of a detailed description and drawings.

Genus 9. *Stannophyllum*, n. gen.[1]

Definition.—Stannomidæ with a thin foliaceous or flabelliform body, arising vertically from a simple short pedicle.

The genus *Stannophyllum* is the largest and the most remarkable of all the Deep-sea Keratosa. It comprises by far the greatest part of the Challenger collection of Keratosa, and is represented by very numerous (more than a hundred) specimens, of which more than half are well developed and tolerably well preserved. All these specimens were brought up from a depth of 2425 fathoms, at that most interesting equatorial Station (271) in the Central Pacific, the bottom of which is covered by a deposit of Globigerina ooze containing many Radiolarian remains, and which supplied the richest treasures in the form of numerous Radiolarian species of all the Challenger stations.

The careful examination of this rich material (regarded by previous observers as "large-sized Rhizopods") has yielded most interesting results, especially from a systematic and phylogenetic point of view. The numerous forms in this important collection may be disposed at least into five different species. These are so widely divergent in external form and shape, as well as in internal structure and composition, that every systematic zoologist would accept them as so-called "good species," provided that they were collected at widely-distant localities, and not connected together by intermediate forms. But they were all taken at the same place (Station 271), and there are so many intermediate forms or connecting links, that the zoologists of the pre-Darwinian epoch would have regarded all these forms as mere varieties of one and the same species, *Stannophyllum flabellum* (compare the Synoptical Table on p. 64).

The body in all the specimens of *Stannophyllum* (Pl. I.) is a thin and flat flabelliform leaf, attached at the bottom of the sea by a small basal pedicle. Probably it stands vertically erect, since the two parallel faces of the leaf are identical in structure. The size of the smaller species (diameter of the roundish leaf) is 4 to 8 cm., that of the larger 12 to 24 cm. The general form of the leaf (without pedicle) is sometimes subcircular or subovate, at other times reniform or palmate. The middle part of the proximal margin is attached by the basal pedicle, which is sometimes short and stout, sometimes long and slender. The distal margin is usually integral and semicircular, but sometimes lobulate or undulate. The surface is usually even and integral, but often coarsely arenaceous, and in one species reticular, pierced by numerous holes.

The striking differences which the five species of *Stannophyllum* show in external shape and internal structure are evidently due in the first instance to the composition of the skeleton and the selection of the various xenophya or foreign bodies which compose it. *Stannophyllum zonarium* (Pl. I. fig. 1) is distinguished by the predominant develop-

[1] *Stannophyllum* = Cement leaf; στέγνος = *Stannum*, cement, solder; φύλλου = leaf.

ment of spongin-fibrillæ and the relatively smaller quantity of xenophya (for the most part Radiolarian shells) which are disposed in the maltha between them. The fibrillæ are very much alike, and regularly arranged in thick crossed bundles (Pl. II. fig. 2). The leaf, therefore, is coriaceous, more elastic and coherent than in the four other species. Its surface is soft and velvet-like, and marked by a number of distinct concentric zones, which run parallel to the semicircular distal margin.

The second species, *Stannophyllum radiolarium* (Pl. I. fig. 2), connected with the first by numerous intermediate forms, is composed almost entirely of Radiolarian shells; the spongin-fibrillæ between them are scarce, very thin, of nearly equal breadth. The leaf, therefore, is homogeneous, and in the dry state is like a thin plate of fine sand; the external surface is quite even, finely arenaceous, without zones and ribs. The physical consistence is rather inelastic, stiff, and fragile.

Whilst in these two species the pseudo-skeleton is composed mainly of siliceous Radiolarian ooze, it consists in the third almost entirely of calcareous Globigerina ooze. The spongin-fibrillæ in the connecting maltha of this *Stannophyllum globigerinum* (Pl. I. fig. 5) are very unequal in size, many coarse and thick between the main mass of thin threads which are irregularly interwoven in all directions like cotton threads. Usually they are more fully developed in the softer medullar plate of the leaf, in which the network of symbiontes expands between the canals of the sponge, and in which the smaller shells and fragments of *Globigerina* are crowded; whereas the two parallel porous dermal plates contain only a small quantity of fibrillæ, and are usually composed for the most part of larger *Globigerina* shells. In consequence of this composition the leaf of this species is extremely flaccid and soft in the wet state, non-elastic, fragile and friable in the dry state. The surface is coarsely granular or sandy, and exhibits sometimes (but not always) indistinct concentric zones, like those of *Stannophyllum zonarium;* with this species it is connected by numerous intermediate forms (compare Pl. I. figs. 1, 5).

The two remaining species, *Stannophyllum venosum* (Pl. I. fig. 4) and *Stannophyllum pertusum* (Pl. I. fig. 3), appear in a certain sense as intermediate forms between *Stannophyllum globigerinum* and *Stannophyllum radiolarium.* They are distinguished by the possession of thick, prominent, branched ribs, which arise from the insertion of the basal pedicle. These thick ribs are whitish, and composed mainly of Globigerina ooze, while the thin brown membrane between them is supported by Radiolarian ooze; the quality and quantity, however, of these two different materials is very variable in the different specimens of these two species, *Stannophyllum venosum* approaching generally nearer to *Stannophyllum globigerinum,* and *Stannophyllum pertusum* to *Stannophyllum radiolarium.* The spongin-fibrillæ are in the two latter species more equal and delicate than in the two former. Besides, *Stannophyllum pertusum* is characterised by the presence of a great quantity of siliceous sponge spicules (mainly Hexactinellida), and perhaps to this is due the greater fragility and flaccidity which characterises this species,

and the origin of the numerous holes which pierce its leaf. But this as well as the characteristic lobulation of the distal margin may be due also partly to the mode of growth, which follows that of the symbiotic Hydroid, partly to the different development of the spongin-fibrillæ (compare p. 64).

The Spongoxeniæ, or the different forms of symbiotic Hydropolyps, which are always present in *Stannophyllum*, expand in the soft medullar mass between the two parallel dermal plates, which may be separated more or less easily from the former. The hydranths seem to proceed usually from the distal margin of the flabelliform leaf, but sometimes also from its two faces and also from the base of the pedicle. Usually the imperfect state of preservation prevents the accurate examination of the disposition and structure of these symbiontes, but in a few specimens (principally of *Stannophyllum globigerinum*) they were well preserved and could be recognised as two species of *Stylactella* (*spongicola* and *abyssicola*, Pl. II. figs. 6, 7), compare below p. 78. The canal-system of *Stannophyllum*, unfortunately, is in most of the specimens badly preserved. I was able, however, to recognise in all the species of *Stannophyllum* the small dermal pores of the surface, but not with satisfaction the larger openings, which may be regarded as oscula. In *Stannophyllum zonarium* there are series of larger openings (twice as broad as the usual pores) in the thickened proximal margin of each zone; in *Stannophyllum globigerinum* sometimes apparent oscula are scattered on the two faces of the leaf, but in the other species they were not distinctly recognisable. It may be that the water entering by the pores of the two parallel faces issues by the oscula of the distal margin (compare Pl. IV. figs. 7, 8). The internal canal-system is of variable shape. Larger or smaller subdermal cavities seem to lie immediately below the dermal plates, and to be connected with groups of flagello-chambers, which are disposed in the spongy medullar substance; these, however, were not distinctly recognisable (compare Pl. II. figs. 3, 4).

Stannophyllum zonarium, n. sp. (Pl. I. figs. 1A–1C; Pl. II. figs. 1–4).

Habitat.—Tropical Pacific, Station 271; September 6, 1875; lat. 0° 33′ S., long. 151° 34′ W.; depth, 2425 fathoms; bottom, Globigerina ooze, containing many Radiolaria.

Sponge with an elastic brown coriaceous leaf of subcircular or kidney-shaped outline, with a thin and flat pedicle. Distal margin semicircular, integral. Surface soft, velvet-like, without branched ribs, but with distinct concentric zones of subequal breadth parallel to the distal margin. Skeleton composed mainly of interwoven bundles of spongin-fibrillæ, and forming a dense felty network, in the meshes of which many shells of Radiolaria and a few fragments of *Globigerina* are imbedded.

Stannophyllum zonarium is the most elastic and flexible among the species here

described; it differs from the others mainly in the composition of the skeleton, in which the interwoven bundles of spongin-fibrillæ predominate, whereas the inorganic xenophya are less numerous. The fibrillæ are much more fully developed than in the other species, and form strong bundles, the smaller of which are composed of ten to twenty, the larger of thirty to fifty or more, parallel fibrillæ. These are nearly equal in size, of medium thickness, their diameter being usually 0·005 mm. on an average (0·002 to 0·008 mm.). Their yellow colour effects the brown tint of the sponge, which is much darker than in the other species. The bundles of fibrillæ are interwoven and cross in all directions, forming an elastic framework, in the smaller meshes of which are imbedded the xenophya, in the larger the canal-system and its flagello-chambers (Pl. II. fig. 2). The xenophya are partly Radiolarian shells, partly fragments of *Globigerina* shells, the former usually much more numerous.

Xenophya.—The foreign bodies which compose the pseudo-skeleton are in *Stannophyllum zonarium* relatively less numerous than in the four other species of the genus; they are for the most part siliceous shells of Radiolaria, mainly in the distal portion of the leaf, while in the basal portion fragments of *Globigerina* shells and fine inorganic particles are intermingled.

External Form.—The flabelliform body of *Stannophyllum zonarium* is easily distinguished from all the other species externally in the softly coriaceous shape of the thick roundish leaf, the two faces of which exhibit sharp concentric zones, but no ribs. The basal pedicle is flat and thin, tapering towards the basal insertion, 10 to 30 mm. long., 1 to 5 mm. thick. The flat leaf is 40 to 60 mm. in diameter, and is sometimes subcircular, at other times reniform, with a flat basal excision. Its thickness is between 1 and 3 mm., usually 1·5 to 2 mm. The colour is deep brown in the wet state, yellow-brown in the dry state. The thick rounded distal margin is integral and not lobate. The two parallel surfaces of the thick leaf exhibit a most striking zonary structure. Numerous concentric deep furrows, which run parallel to the semicircular distal margin, divide both faces into zones or bands of subequal breadth (between 3 and 5 mm., usually 4 mm.). The proximal part of the concentric bands is somewhat thicker than the distal, so that they exhibit a slight imbrication. This zonary structure presents a striking similarity to that of two other flabelliform but widely remote organisms, viz., *Flustra foliacea* (Bryozoa) and *Zonaria pavonia*, Ag. *Padina pavonia*, Grev. (Fucaceæ Dictyoteæ); even the breadth of the concentric zones is usually about the same.

The consistence of this species is much denser and more elastic than in any of the other species of the genus, owing to the much stronger development of the spongin-fibrillæ and the smaller quantity of imbedded xenophya. The thin dermal membrane is denser and more coherent than in the others, and the medullar substance is also more consistent. The dermal pores are very small and regular.

Synoptical Table of the Five Species of Stannophyllum, showing the Specific Characters in External Form and Internal Structure of these Five Transitional Species.

Species.	Material of the Skeleton.	Network of the Fibrillæ Bundles.	Spongin-Fibrillæ.	Consistency of the Flabelliform Leaf.	Distal Margin of the Leaf.	Faces of the Leaf.	Colour.	Size (Diameter of the Leaf).
I. *Stannophyllum zonarium* (Pl. I. fig. 1).	Spongin-fibrillæ prevailing, with many Radiolarian shells.	Very dense and regular, with thick bundles crossed in certain directions.	Very much alike, of medium thickness.	Thick, soft and elastic.	Reniform, integral, rather thick.	With concentric equal zones, coriaceous.	Brown (yellowish).	4 to 8 centimetres.
II. *Stannophyllum radiolarium* (Pl. I. fig. 2).	Siliceous Radiolarian shells prevailing, with few spongin-fibrillæ.	Rather dense and regular, with thin bundles, or many isolated.	Very thin and delicate, of nearly equal thickness.	Thin, rather solid and rigid.	Semicircular, integral, very thin.	Finely granular, even, without zones and ribs.	White or light grey (yellowish).	3 to 6 centimetres.
III. *Stannophyllum pertusum* (Pl. I. fig. 3).	Radiolarian shells prevailing in the distal part, *Globigerina* shells in the ribs and the proximal part.	Rather loose and irregular, especially in the basal portion.	Rather unequal, for the most part thin and interwoven.	Thin, very soft and flabby, inelastic.	Reniform, divided into numerous quadrangular lobes.	Reticular, pierced by numerous holes, very soft, with ribs, without zones.	Brown with greyish ribs.	10 to 20 centimetres.
IV. *Stannophyllum venosum* (Pl. I. fig. 4).	Radiolarian shells prevailing in the distal part, *Globigerina* shells in the ribs and the proximal part.	Very irregular and loose, especially in the ribs, denser in the lamellæ between them.	Very unequal, thick and coarse in the ribs, thin in the lamellæ between them.	Heteromorphous, with thick prominent ribs or veins, and thin tissue between them.	Semicircular, more or less irregularly lobulate or undulate.	Veined, with thick white branched ribs, without zones.	Brown, with white ribs.	20 to 25 centimetres.
V. *Stannophyllum globigerinum* (Pl. I. fig. 5).	Calcareous *Globigerina* shells prevailing, with scanty Radiolarian shells.	Very irregular and loose, felty, interwoven in all directions.	Very unequal, of varying diameter, many coarse between prevailing fine threads.	Thick, very fragile and flabby, inelastic.	Subovate or truncate, integral, not lobate, very thick.	Coarsely granular, very rough, without ribs, often with indistinct zones.	White or yellowish (greyish).	6 to 9 centimetres.

Stannophyllum radiolarium, n. sp. (Pl. I. figs. 2A–2C).

Habitat.—Station 271; depth, 2425 fathoms; bottom, Globigerina ooze.

Sponge with a thin, homogeneous, whitish, flabelliform or reniform leaf, in the basal margin of which a long slender pedicle is inserted. Distal margin hemielliptical, integral. Surface finely granular, without concentric zones and without ribs. Skeleton composed mainly of siliceous Radiolarian shells. Spongin-fibrillæ between them very thin and delicate, many isolated, others aggregated in small bundles.

Stannophyllum radiolarium is the most delicate and fragile among the species here described, differing from the others mainly in the composition of the pseudo-skeleton; this is composed almost entirely of siliceous Radiolarian shells, between which a scanty maltha is developed, including the spongin-fibrillæ. These are less fully developed and thinner than in any of the other species, and run for the most part isolated or in very small bundles (composed of four to eight fibrillæ, rarely twelve to sixteen or more). The diameter of the fibrillæ is usually between 0·001 and 0·002 mm., often less, rarely more (0·003 to 0·005 mm.).

External Form.—The colour of this species in the dry state is whitish or light yellowish grey. The thickness of the thin and delicate leaf is only 1 to 1·5 mm. (more rarely 2 to 2·5 mm.); its diameter is usually between 30 and 50 mm., and the length of the slender pedicle is about the same. The semicircular margin of the leaf is integral. The two parallel surfaces are nearly smooth, quite even, pierced by very small pores, without concentric zones and without ribs. In the elasticity and consistence of the dry leaf this species is intermediate between *Stannophyllum zonarium* and *Stannophyllum pertusum*. It is connected with both species by transitional forms. The dermal pores are smaller than in the latter, and its finely granular even surface distinguishes this species at once.

Xenophya.—The pseudo-skeleton of this species is a fine collection of Radiolarian shells. The majority of the numerous species of Spumellaria and Nassellaria, which are found in the ooze of Station 271, are to be found aggregated in the skeleton of this delicate sponge, connected by a small quantity of clear maltha, and separated by the numerous thin spongin-fibrillæ, which form a rather regular network between the branches and in the meshes of the symbiotic Hydroid.

Stannophyllum pertusum, n. sp. (Pl. I. figs. 3A, 3B).

Habitat.—Station 271; depth, 2425 fathoms; bottom, Globigerina ooze.

Sponge with a broad, reniform or flabelliform leaf, in the basal margin of which a slender triangular pedicle is inserted. Distal margin semicircular, with numerous

quadrangular lobes and deep incisions. Surface reticular, pierced by numerous holes, very soft, without concentric zones, but with more or less distinct ribs or branched veins. Skeleton composed mainly of Radiolarian shells and siliceous sponge spicules, intermingled in the ribs with numerous *Globigerinæ;* spongin-fibrillæ thin and of nearly equal breadth, loosely interwoven.

Stannophyllum pertusum differs externally very strikingly from the other species of the genus by the numerous lobes of the distal margin and the holes which pierce the reniform leaf and produce its reticular appearance; these characters, however, are found less prominently in the closely-allied *Stannophyllum venosum*, with which it is connected by intermediate forms. The branched ribs of the latter species, too, are usually more or less indicated, but rarely so prominent. The shape of the two species is also similar, produced by the same composition of the skeleton. This contains a loose framework of interwoven spongin-fibrillæ of various sizes, and imbedded in its meshes a variable quantity and quality of xenophya.

Xenophya.—The aggregation of foreign bodies which compose the pseudo-skeleton is a variable mixture of Radiolarian remains and of Globigerina ooze, the latter usually predominating in the proximal portion of the leaf, its ribs and the pedicle, the former in the distal portion and in the thin lamellæ between the ribs. The numerous specimens in the Challenger collection vary a great deal in this respect; when the siliceous shells of Radiolaria are predominant, the structure of the leaf approaches that of *Stannophyllum radiolarium;* when the calcareous shells of the Foraminifera are abundant, it is more like that of *Stannophyllum globigerinum.* The spongin-fibrillæ are also very variable, thinner and finer in the former, thicker and coarser in the latter. The leaf of the latter is far more flabby, soft, and inelastic than that of the former. In some specimens a great quantity of siliceous spicules of sponges (mainly Hexactinellidæ) is embedded in the clear maltha, and these specimens are particularly flabby and easily torn.

External Form.—The general form of the leaf in *Stannophyllum pertusum* is kidney-shaped; its diameter is between 80 and 120 mm., but some larger specimens seem to reach 200 mm. or more, and approach near to *Stannophyllum venosum.* The semicircular or crescentic distal margin is always lobate, with a great number (forty to sixty or more) of radial incisions, by which the rounded quadrangular lobes are separated. The irregular roundish holes which pierce the flat leaf are evidently produced by the growing together of formerly separated marginal lobes. Their size and number is very variable. Probably the approachment of divergent branches of the symbiotic reticular Hydrocaulus (Spongoxenia) is the first cause of this formation. The proximal margin of the leaf is integral, broadly triangular, and tapers into a slender triangular pedicle. This has a length of 30 to 50 mm., a breadth of 4 to 8 mm., and is attached by a basal plate at the bottom of the sea.

Stannophyllum venosum, n. sp. (Pl. I. fig. 4).

Habitat.—Station 271 ; depth, 2425 fathoms ; bottom, Globigerina ooze.

Sponge with a broad flabelliform or reniform leaf, in the basal incision of which a stout and short pedicle is inserted. Distal margin semicircular, undulate and lobulate. Surface distinctly veined, with numerous thick, whitish, branched ribs, which diverge from the insertion of the pedicle ; between them thin, flabby, brown lamellæ. In the ribs the skeleton is composed mainly of calcareous Globigerina ooze, in the lamellæ of siliceous Radiolarian tests ; spongin-fibrillæ thick and coarse in the former, thin and fine in the latter.

Stannophyllum venosum, represented in Pl. I. fig. 4 half natural size, is the largest of all the Deep-sea Keratosa, the longitudinal diameter of the flabelliform leaf reaching 200 mm. and the transverse diameter 250 mm. It is distinguished at once from the other four species of the genus by the strong, prominent, white ribs or veins arising divergently from the insertion of the thick basal pedicle and tapering towards the thin lobulate margin. The pseudo-skeleton of these thick whitish ribs is composed principally of calcareous Globigerina ooze, while that of the thin yellowish or brown lamellæ between them consists for the most part of siliceous Radiolarian shells. The spongin-fibrillæ are very unequal in size, thicker and rather coarse in the ribs, thinner and finer in the lamellæ between them, the network formed by them being loose and irregular in the former, denser and finer in the latter.

External Form.—In the largest specimens there are seven of the peculiar thick veins or branched ribs, which are prominent on the two faces of the thin flaccid leaf. In the middle there is an odd rib, or a prolongation of the thick basal pedicle, and three divergent pairs on each side, each rib being again branched or beset with secondary ribs. The tapering distal ends of the branches pass gradually over into the thin brown web of the distal portion of the leaf, which is very flabby and easily torn. The development of these ribs seems to be produced partly by strong bundles of reticular symbiotic Hydroids, partly by strong bundles of coarser spongin-fibrillæ (0·006 to 0·01 mm. in diameter), strengthened by crowded Globigerina ooze ; the thin brownish membrane between the thick whitish ribs is composed mainly of Radiolarian tests and of thinner fibrillæ (0·001 to 0·002 mm. in diameter).

The thick and short basal pedicle which is inserted into the proximal portion of the reniform leaf is 20 to 30 mm. in length and 6 to 8 mm. in thickness. It is attached to the sea-bottom by a basal plate, 15 to 20 mm. in diameter. The thickness of the lamellar leaf diminishes gradually towards the very thin and flabby distal margin, which is slightly undulate and lobulate ; sometimes the distal portion of the leaf is pierced by small irregular holes, but neither these perforations nor the marginal lobes are so pronounced as in the closely-allied *Stannophyllum pertusum*.

Xenophya.—The foreign bodies which compose the pseudo-skeleton of this, the largest, species seem to offer a new argument in favour of my opinion, that such a pseudo-skeleton is constructed, in the Psammospongiæ as well as in other animals (for instance, in the Physemaria, &c.), with a certain amount of selection of materials, for the skeleton of the thick ribs approaches that of *Stannophyllum globigerinum*, whilst that of the thin membrane between them is more like that of *Stannophyllum radiolarium*.

Stannophyllum globigerinum, n. sp. (Pl. I. figs. 5A–5C).

Habitat.—Station 271; depth, 2425 fathoms; bottom, Globigerina ooze.

Sponge with a flabby, white, arenaceous leaf of subovate or triangular outline, the tapering base of which is supported by a conical pedicle. Surface coarsely granular, friable, without radial ribs, but often with more or less distinct concentric zones. Skeleton composed mainly of calcareous Globigerina ooze, the shells and fragments of which are larger in the two cortical faces, smaller in the medullar mass between them. Spongin-fibrillæ very unequal in size, many coarser and branched between the interwoven finer ones.

Stannophyllum globigerinum is the opposite end in the series of continuous links which are presented by the five species of this genus, beginning with the coriaceous *Stannophyllum zonarium*. In contrast to this latter the true fibrillar skeleton is here very weak, especially in the dermal plates, and the main mass of the arenaceous leaf is a pseudo-skeleton, composed almost entirely of Globigerina ooze. Intermingled between the shells and fragments of *Globigerina* and *Pulvinulina* there occur many small siliceous shells of Radiolaria, in far smaller quantity, however, than in the other four species. The spongin-fibrillæ which support the cementing maltha are of very unequal and irregular shape, and are most irregularly interwoven in all directions. There are many very thick fibres, 0·006 to 0·01 mm. in diameter and more, and in these the medullar or axial thread is twice as broad as the surrounding cortical wall. The thickest fibrillæ are often richly branched, and sometimes begin to anastomose (transition to *Psammophyllum*).

Xenophya.—The foreign bodies which compose the pseudo-skeleton of this species are in the majority of the numerous preserved specimens almost wholly calcareous shells of Globigerina ooze, and their fragments; usually the two parallel dermal plates of the foliaceous body are composed of larger shells, the softer medullar mass between them of smaller shells and fragments; within this latter is expanded the rich brown network of the symbiotic Hydroid. The scanty maltha between the fibrillæ includes often rather numerous Radiolarian shells, and, in the basal pedicle, sponge spicules.

External Form.—The flabelliform body of *Stannophyllum globigerinum* is easily

distinguished from the other species externally in the arenaceous and coarsely-granular appearance of the white surface, due to the large, densely crowded, *Globigerina* shells which compose the two thick, parallel, dermal plates. The dry sponge, therefore, is very stiff, friable and fragile, arenaceous and inelastic. In the wet state it is extremely flaccid, and may be easily torn. The outline of the leaf is usually ovate or obliquely elliptical; its thickness is considerable, and nearly equal throughout its whole extent, about 2 to 3 mm., sometimes 4 mm. or more. The diameter of the leaf is usually between 40 and 60 mm., sometimes 80 to 90 mm., or even more. The tapering proximal part is prolonged into a conical pedicle of variable thickness, the basal insertion of which is often bulbous. Sometimes the thick pedicle is prolonged as a prominent median rib in the proximal half of the leaf, gradually tapering distally. The coarsely-granular surface of the leaf usually exhibits more or less distinct traces of the concentric zones which are characteristic of *Stannophyllum zonarium*, but they are never so regular nor so distinct as in that species, and sometimes they are absent altogether.

A few specimens of this species were distinguished by the production of one or two surface lobes arising from one or both sides of the leaf (Pl. I. fig. 5B). This production forms a transition to the genus *Stannarium* (Pl. III. figs. 6–14).

Stannophyllum globigerinum is the fittest for anatomical examination of all the five species of this genus, for the greatest part of the skeleton, viz., the calcareous Globigerina ooze, is easily dissolved in hydrochloric acid. The remaining portion of the body is partly a scarce maltha (sometimes containing ova), partly a very loose felty mass, composed of irregular bundles of spongin-fibrillæ, interwoven in all directions, and of the branched canals of the sponge, which run between the brown network of the symbiotic Hydroid. The reticular hydrorhiza of this latter is usually richly developed, and may be more easily isolated than in the other species of the genus (Pl. II. fig. 5). In a few specimens the hydranths (*y''*) and gonangia (*g*) were well preserved, and could be recognised as belonging to two distinct species of *Stylactella* (*Stylactella spongicola*, Pl. II. fig. 6; and *Stylactella abyssicola*, fig. 7).

Genus 10. *Stannarium*,[1] n. gen.

Definition.—Stannomidæ with branched lamellar body, forming vertical plates, which arise as lateral branches from a primary flabelliform body.

The genus *Stannarium* comprises those Stannomidæ in which the body is composed of several vertical leaves, which are either free or growing together. There can be no doubt that this peculiar form has originated from *Stannophyllum* by lateral budding, and that two opposite of these vertical wings are the halves of the primary flabelliform leaf

[1] *Stannarius* = Cementing or soldering workman.

(*Stannophyllum*), whilst all the others are secondary wings, budding from its two parallel faces (compare Pl. I. fig. 5B). The internal structure as well as the external form of these leaves are the same as in the ancestral *Stannophyllum*, and the material of the pseudo-skeleton is variable in a similar way.

Two different species of *Stannarium* were found in the Challenger collection, the first (*Stannarium alatum*) with free wings, the second (*Stannarium concretum*) with united wings, so grown together that funnel-shaped cavities remain between them. The pseudo-skeleton of the former is composed mainly of Radiolarian ooze, while in the latter more or less Globigerina ooze is intermingled. The spongin-fibrillæ are more regular, equal, and thin in the former, coarser and unequal in the latter, so that the differences between these two species are similar to those between their ancestral forms, *Stannophyllum radiolarium* and *Stannophyllum globigerinum*.

Stannarium alatum, n. sp. (Pl. III. figs. 6–9).

Habitat.—Central Pacific, Station 272; September 8, 1875; lat. 3° 48′ S., long. 152° 56′ W.; depth, 2600 fathoms; bottom, Radiolarian ooze.

Sponge rather consistent, with several vertical, free, foliaceous wings, which are not grown together, and arise from a primary flabelliform leaf. Skeleton composed mainly of Radiolarian ooze.

There are several specimens of *Stannarium alatum*, varying in diameter from 30 to 60 mm. From a thick basal pedicle arises vertically a primary flabelliform leaf (*Stannophyllum*), and this produces by lateral budding several secondary leaves, which also stand nearly vertical. Usually there are two larger secondary leaves arising obliquely from the two sides of the primary leaf, so that the sponge seen from above represents an irregular four-winged cross (fig. 8). Sometimes several smaller lateral wings arise between the larger. The wings are ovate, or semicircular, of the same thickness as the primary leaf, between 1 and 2 mm. The distal margins are integral or slightly lobulate.

The surface of the leaves is finely arenaceous (from the conglomeration of Radiolarian shells), and at the same time felty (from the irregular web of the fine spongin-fibrillæ). Innumerable very small pores pierce the thin dermal membrane, which may be stripped off from the dense, felty, medullar mass. This is rather compact, traversed by the same canal-system and the same network of the symbiotic Hydroid as in the ancestral *Stannophyllum radiolarium*.

Skeleton.—Amongst the xenophya or foreign bodies which compose the pseudo-skeleton, siliceous Radiolarian shells are predominant, but sometimes spicules of siliceous sponges and also fragments of calcareous *Globigerina* shells are intermingled, the latter mainly in the basal pedicle. All the xenophya are surrounded and connected by the

clear maltha, in which the framework of the spongin-fibrillæ is imbedded. These are very thin and fine (for the most part between 0·001 and 0·003 mm. in diameter), exhibit a distinct medullar thread or axial canal, and are densely interwoven in all directions. The main support of the body is formed by the network of the symbiotic Hydroid, which is expanded in the medullar substance of the sponge.

Stannarium concretum, n. sp. (Pl. III. figs. 10–14).

Habitat.—Central Pacific, Station 270; September 4, 1875; lat. 2° 34′ N., long. 149° 9′ W.; depth, 2925 fathoms; bottom, Globigerina ooze.

Sponge rather flabby, with several vertical foliaceous wings, which are grown together and surround one or more funnel-shaped cavities. Skeleton composed mainly of Globigerina ooze.

Stannarium concretum has a peculiar appearance, produced by the coalescence of the irregular lateral wings, which arise vertically from the two sides of the primary leaf (*Stannophyllum*). Usually there are between four and eight wings of different sizes, and these grow together with their faces touching in such a manner, that one or more infundibular cavities are formed between them. A subregular form, of rather firm consistence, is shown in figs. 10–12, where four vertical wings are so crossed that they form together a four-sided pyramid with four prominent edges, and a funnel-shaped central cavity at the top (fig. 11). Two opposite wings of these four represent the primary leaf; the other two, also opposite to one another, arise from the median line of the two parallel faces of the former; their separate roots growing together with the former enclose the pyramidal central cavity. Another specimen of very flabby consistence is composed of eight irregular vertical wings, four larger and four smaller (fig. 13 from above, fig. 14 from one side). The thickness of these leaves is between 2 and 4 mm., the diameter of the whole sponge between 20 and 50 mm.

Skeleton.—The surface of the leaf is in this species far more coarse and granular than in the preceding, and the consistence softer and flabbier. This is produced by the different composition of the skeleton, in which a great quantity of calcareous Globigerina ooze is mixed with the siliceous Radiolarian remains. Sometimes the former predominates. *Globigerina* shells and their fragments compose mainly the two parallel dermal plates, while in the soft medullar mass between them they are intermingled in different degrees with Radiolarian shells. The greater the proportion of Globigerina ooze, the more unequal become the spongin-fibrillæ of the skeleton, very coarse ones (0·006 to 0·008 mm. in diameter and more) being intermingled with finer ones (0·002 to 0·004 mm. or less); they are interwoven irregularly in all directions. Between this felty mass and the xenophya, surrounded by the fibrillæ-bundles, there is expanded the network of the symbiotic Hydroid.

Genus 11. *Stannoma*, n. gen.[1]

Definition.—Stannomidæ with arborescent body, divided into numerous free or anastomosing cylindrical branches.

The genus *Stannoma* differs from the other Stannomidæ in the arborescent form of the body, which is like a small tree or coral stock. The ramifications of the corm are sometimes regular and dichotomous, at other times irregular.

Two species of *Stannoma* were found in the Challenger collection, both taken at two neighbouring stations in the Central Pacific, viz., Station 271 (2425 fathoms) and Station 272 (2600 fathoms). The Radiolaria in the ooze covering the bottom at these two stations make up the pseudo-skeleton in both species; the xenophya are imbedded in a scanty clear maltha, which is supported by a dense framework of thin spongin-fibrillæ.

The branches of the arborescent body are cylindrical in both species. They are free in *Stannoma dendroides* (Pl. III. fig. 1), while they anastomose and form a loose network (similar to *Clathria*) in *Stannoma coralloides* (Pl. III. fig. 5). A transverse section (Pl. III. figs. 2, 3) shows numerous brown tubes of the symbiotic Hydroid (*h*); the tubes seem to belong to two different genera (*Stylactis*, *Halisiphonia*). The branches of the reticular hydrorhiza give a firm support to the arborescent sponge, and between them branch its canals, the course of which could not be made out. The dry *Stannoma* is very light and friable, the surface loosely woolly and finely sandy; the dermal membrane which covers the surface of *Stannophyllum* is absent here.

Stannoma dendroides, n. sp. (Pl. III. figs. 1–4).

Habitat.—Tropical Pacific, Station 271; depth, 2425 fathoms; bottom, Globigerina ooze. Station 272; depth, 2600 fathoms; bottom, Radiolarian ooze.

Sponge arborescent, irregularly branched (partly dichotomous, partly polychotomous), with slender cylindrical branches tapering towards the conical distal end. Branches free, without anastomoses.

The body of the tree-like sponge is 30 to 50 mm. high, 20 to 30 mm. broad, very soft and flexible, in the dry state friable. The short stem, 10 to 20 mm. in height, 3 to 5 mm. in thickness, is either cylindrical or inversely conical, tapering towards the small base, and divided into three to six stout main branches, 3 to 4 mm. in diameter. These divide again into secondary and tertiary branches of varying lengths, between

[1] *Stannoma* = Cemented body, στεγνώμα.

5 and 20 mm. The branches are slightly curved, and gradually taper from 3 or 2 mm. to 0·5 mm. or less in thickness; the conical end also tapers gradually.

Internal Structure.—Transverse and longitudinal sections through the branches of the arborescent sponge (Pl. III. figs. 2, 3) exhibit a loose framework of the symbiotic Hydroid (Spongoxenia), and between its meshes are the branches of the canal-system of the sponge and its skeleton, which is composed of Radiolarian ooze and of spongin-fibrillæ, connected by the scanty clear maltha. The structure of the canal-system, and especially the disposition of the flagello-chambers, unfortunately, could not be made out, owing to the bad state of preservation of the tissues. The woolly surface of the branches is porous, but they have no distinct dermal membrane.

Fibrillæ.—The fine spongin-fibres are scantily developed, and form an irregular very loose framework throughout the whole maltha of the mesoderm. They are for the most part not arranged in bundles, but isolated and very loosely interwoven in all directions, in the medullary as well as in the cortical substance. Ramifications of the fibrillæ were not observed; their usual diameter is between 0·001 and 0·003 mm., often less, rarely more (figs. 2, 3, *f*). The fibrillæ are imbedded in the scanty clear maltha which connects the foreign bodies (*r*).

Xenophya.—The foreign bodies compose the main mass of the sponge (probably 90 to 95 per cent. of the solid substance); they are almost exclusively siliceous shells of Radiolaria; rarely small fragments of Hyalospongiæ or Hexactinellidæ are found among the Radiolaria (fig. 4).

Symbiontes.—The tubular hydrorhiza of the symbiotic Hydroid, which supports the sponge and all its branches, forms an irregular network with large and loose meshes, usually five to ten times as long as broad; in transverse sections of the branches usually twenty to thirty or more tubes are visible, usually 0·06 to 0·08 mm. in diameter. They appear to belong to two different genera, viz., *Stylactis* (Pl. II. figs. 5–7) and *Halisiphonia* (Pl. IV. fig. 9).

Stannoma coralloides, n. sp. (Pl. III. fig. 5).

Habitat.—Tropical Pacific, Station 271; depth, 2425 fathoms; bottom, Globigerina ooze. Station 272; depth, 2600 fathoms; bottom, Radiolarian ooze.

Sponge arborescent or coral-shaped, irregularly branched (usually dichotomous), with short cylindrical branches of equal thickness, truncated or club-shaped at the distal end. Branches anastomosing and forming a network.

The reticular body of the coralliform sponge is of subglobular outline, 30 to 40 mm. high, and in the distal part about the same in breadth. The short stout stem, 3 or 4 mm. high, divides into numerous short and stout cylindrical branches, which are again

dichotomously branched. The cylindrical branches are connected by numerous anastomoses and form a loose network, the meshes of which are 2 to 5 mm. in diameter. The thickness of most of the branches is between 2 and 3 mm. The distal ends are rounded or nearly truncate, sometimes club-shaped, not tapering or conical, as in the preceding species. These differences, and especially the reticular shape of the sponge, might perhaps justify its separation as a peculiar genus (*Stannoplegma*).

Internal Structure.—Transverse and longitudinal sections through the branches of the coralliform sponge exhibit the same structure as in the preceding species, viz., a loose framework of the symbiotic Hydroid (Spongoxenia), and between its meshes are the branches of the canal-system of the sponge, and the skeleton composed of Radiolarian ooze and of spongin-fibrillæ. The anatomical structure of the canal-system here also could not be made out.

Fibrillæ.—The fine spongin-fibres are much more numerous, larger and more richly developed, than in the preceding species; they are arranged partly in bundles, partly interwoven in all possible directions, in the cortical as well as in the medullary mass. Most of the fibrillæ are simple and run isolated, but often two to six parallel fibrillæ are found associated; more rarely there are small bundles of ten to twenty or more. Ramifications of the fibrillæ, which I could not find in *Stannoma dendroides*, are not rare in *Stannoma coralloides*. The diameter of the larger fibres is 0·005 to 0·01 mm., that of the smaller fibres 0·001 to 0·004 mm., often less. The firmer consistence of this species is mainly produced by the richer development of the fibrillæ, which surround and connect the xenophya, or the foreign bodies composing the main mass of the sponge; these are, as in the preceding species, almost exclusively Radiolarian shells (figs. 2–4, *r*).

Symbiontes.—The chitinous tubes of the symbiotic Hydroid are in this species less numerous than in the preceding; a transverse section of the branches exhibits usually ten to fifteen tubes, rarely more, often less. The network of the tubes is in *Stannoma coralloides* much looser than in *Stannoma dendroides;* the Hydroid is apparently *Halisiphonia spongicola* (Pl. IV. fig. 9).

APPENDIX.

Symbiotic Hydroida living in the Deep-sea Keratosa.

The majority of the Deep-sea Keratosa described in the preceding pages live constantly in symbiosis with certain Hydroids, viz., all the Stannomidæ (nine species), all the Spongelidæ (five species), and a part of the Psamminidæ (two species). No symbiotic Hydroida were found in the remainder of the Psamminidæ (five species) nor in the Ammoconidæ (five species). The symbiosis and the mutual relations between the Deep-sea Keratosa and the Hydroida seem to be so important for both parts of the organism (at least in the majority of the species enumerated) that the whole growth, the general form, and the special structure have been modified by their influence.

In spite of the imperfect state of preservation, which presented great obstacles to the recognition of the symbiotic animals, I have been able, by continuous examination of numerous specimens, not only to state with sufficient certainty the Hydroid nature of the reticular symbiontes hidden in the Keratose body, but also to distinguish at least four different forms, in three of which the genus could be recognised. Two species (one of which is the most frequent inhabitant of the sponges) belong to the genus *Stylactis*, Allman (Pl. II. figs. 5–7); a third species to *Halisiphonia*, Allman (Pl. IV. fig. 9); and a fourth probably to *Eudendrium* or an allied genus (Pl. IV. fig. 4).

The characters common to all these symbiotic Hydroida are: (1) the enormous development of a reticular hydrorhiza; (2) the small size of the hydranths arising from it; (3) the production of sporosacs or sessile gonophores directly from the hydrorhiza; (4) the production of a dark (brown or greenish) pigment in the entoderm cells.

Hydrorhiza of the Symbiotic Hydroida.—The hydrophyton (Allman) or the common basis of the trophosome, by which its zooids are connected into a single colony, is represented in all the symbiotic Hydroids not by a free branched hydrocaulus, but by a reticular hydrorhiza, which is fully enclosed in the body of the hospitable sponge. Usually all the parts of the sponge are traversed by the network of the hydrorhiza, but sometimes this is confined to a certain part of the host, while the other part is free.

The anastomosing branches of the hydrorhiza are usually cylindrical and of nearly equal diameter in the majority of specimens, but sometimes they form irregular dilata-

tions, either between two neighbouring branches or on the connecting nodal points of the network, and then its configuration becomes more irregular (Pl. II. fig. 7, *h*). The meshes of the network are usually roundish or polygonal, sometimes more oblong; their diameter is very variable, but usually small (Pl. II. figs. 5, 6, *h*).

Perisarc.—The chitinous tube which surrounds the tubular branches of the reticular hydrorhiza is of special physiological importance to the symbiotic Deep-sea Keratosa, since it replaces the absent strong spongin-fibres. The network of the perisarcal tubes forms the firm pseudo-skeleton of the soft sponges, and constitutes the solid framework which supports their canal-system. It is very probable that the absence of the usual strong spongin-fibres in these Deep-sea Keratosa is effected by the association with the symbiotic Hydroids, the growth of which determines the form of the sponge.

Cœnosarc.—The soft and delicate epithelia of the cœnosarc (ectoderm and entoderm) hidden in the chitinous tubes of the perisarc were usually scarcely recognisable, and more or less destroyed in the specimens examined; they presented the same difficulties in examination as the epithelia of the sponge itself, being much injured by the conditions of capture and the sudden change of the physical conditions of existence. In a few cases, however, they were tolerably well preserved, and I was able to convince myself that the wall of the tubular cœnosarc possesses the same structure as in the smaller Hydroids. A striking character of these deep-sea Hydroids is the dark coloration of the cœnosarc produced by the accumulation of brown, greenish, or blackish pigment-granules. These are very similar to the phæodella, or the peculiar pigment-granules, which constitute the phæodium, or the extra-capsular pigment-body of the Phæodaria, described in my Report on the Challenger Radiolaria.[1] The striking similarity of these dark pigment-bodies, and their general presence in the cœnosarc and the hydranths of the symbiotic Hydroids, caused some naturalists, who examined these Keratosa, to declare them to be "large-sized Rhizopods with reticular tubes filled up by phæodia." This mistake is the more conceivable, as usually the epithelia of the cœnosarc are destroyed, and their scattered pigment-granules fill up the cavity of the perisarcal tubes.

Hydranths.—The nutritive zooids of the symbiotic deep-sea Hydroids are small, and were in all the specimens examined highly contracted, usually more or less injured, so that it was no easy task to recognise their true nature with certainty. This was possible, however, in the case of *Stylactis spongicola* inhabiting *Stannophyllum*, and especially in those species in which the pseudo-skeleton is composed of Globigerina ooze. After having dissolved the calcareous matter by hydrochloric acid, I could observe hundreds of hydranths arising from the superficial layer of the hydrorhiza, and prominent on the dermal surface of the sponge. The hydranths were ovate or club-shaped, sessile in *Stylactis spongicola*, shortly pedunculated in *Stylactis abyssicola*, and had a diameter of 0·2 to 0·3 mm. in the former, 0·5 to 0·6 mm. in the latter. The tentacles were

[1] Zool. Chall. Exp., pt. xl. vol. xviii. p. 1532.

usually contracted, turned inwards to the mouth, and difficult to distinguish, but sometimes they were prominent over the conical hypostome, and formed a single circlet, composed of eight to sixteen cylindrical tentacles (Pl. II. figs. 5–7, *y*). The entoderm of the hydranths exhibited the same dark coloration as that of the hydrorhiza.

The hydranths of *Halisiphonia spongicola* (a Campanularian Hydroid allied to *Lafoëa*) were not preserved in the few specimens of Stannomidæ in which it occurred; but in this case the chitinous hydrotheca, very similar to that of *Halisiphonia megalotheca* (Allman), permitted me to recognise the genus of the symbiotic Hydroid.

Gonophores.—Sexual zooids bearing eggs in their walls were observed in both species of *Stylactis*, but not in *Halisiphonia;* they were, however, rare, and not found in the majority of hydrosomes. They were in both species ovate or club-shaped naked bodies, which arose from the hydrorhiza between the hydranths (Pl. II. figs. 6, 7, *g*). *Halisiphonia* exhibited a few chitinous oviform gonangia (Pl. IV. fig. 9, *g*). The entoderm of the gonophores in *Stylactis* is of the same dark phæodium-like colour as that of the hydrorhiza and the hydranths.

Halisiphonia spongicola, n. sp. (Pl. IV. fig. 9).

Habitat.—North Pacific, Station 241; depth, 2300 fathoms. Central Pacific, Station 272; depth, 2600 fathoms; symbiotic with *Stannoma* and *Psammophyllum.*

Halisiphonia with a reticular hydrorhiza, the anastomosing tubes of which are cylindrical, of equal breadth. Hydranths probably cylindrical, enclosed in a slender cylindrical hydrotheca, which arises by a thin and short pedicle from the hydrorhiza. Gonangia ovate, with a circular opening, twice as broad and about as long as the hydothecæ, arising scattered between them from the hydrorhiza.

Halisiphonia spongicola is very similar to *Halisiphonia megalotheca*, described by Allman.[1] This latter species was collected by the Challenger at Station 160 (south of Australia), at a depth of 2600 fathoms. Allman gives the following description of it:—"Hydrocaulus a creeping and adherent tube which supports at irregular intervals pedunculated hydrothecæ. Hydrothecæ very large, cylindrical, gradually passing below into the long smooth cylindrical peduncle. Gonangia spathuliform, borne on short peduncles, and with the summit opening by a long narrow transverse slit."

The trophosome of *Halisiphonia spongicola* is very similar to the figure given by Allman, but its network is much more developed, and traverses the whole body of *Psammophyllum flustraceum* (p. 52, Pl. IV. fig. 5), and probably also that of *Stannoma coralloides* (Pl. III. fig. 5); from the surface of the former is prominent only the distal part of the hydrothecæ, with their openings. It seems, therefore, more reasonable to call the trophosome of this symbiotic species hydrorhiza (as in *Stylactis*),

[1] Zool. Chall. Exp., pt. lxx. p. 31, pl. xvi. figs. 1, 1*a*.

not hydrocaulus. The entoderm of the cœnosarc, enclosed in the chitinous cylindrical tubes of the perisarc, is of the same dark colour as in *Stylactis*. A few gonangia were observed scattered between the hydrothecæ and arising immediately from the perisarcal network (fig. 9, *h*). They had the same size and subovate form as those of *Halisiphonia megalotheca*, but they were not compressed or spathuliform, with a slit-shaped opening; their transverse section and the distal opening are circular (fig. 9, *g*).

The genera Stylactis and Stylactella.

The genus *Stylactis* was founded in 1864 by Allman, in his leading paper on construction and limitation of genera among the Hydroids.[1] It is the first genus of the family Podocorynidæ, and one of the most primitive among the Tubulariæ or Gymnoblastic Hydroids. Allman's definition of *Stylactis* is as follows :—"*Trophosome:* Cœnosarc mainly composed of a retiform hydrorhiza, which consists of anastomosing tubes invested by a periderm; hydrocaulus rudimental or absent. Polypites claviform, with a single verticil of filiform tentacles surrounding the base of a conical metastome. *Gonosome:* Gonophores adelocodonic, borne on the body of the polypite at the proximal side of the tentacles." Two species are mentioned, *Stylactis fucicola* (=*Podocoryne fucicola*, Sars) and *Stylactis sarsii*, Allman (=*Podocoryne carnea*, Sars).

Similar to this first definition of *Stylactis* by Allman is the one which he gave in 1871, in his excellent Monograph of the Gymnoblastic or Tubularian Hydroids,[2] where he describes a third species, *Stylactis inermis* (p. 306). But afterwards, in his Challenger Report,[3] the definition of *Stylactis* was essentially altered, and given in the following words:—"*Trophosome:* Hydrocaulus rudimental, being reduced to short tubular processes, which spring at intervals from a creeping, stolon-like hydrorhiza and support the hydranths on their summit; hydrorhiza destitute of external cœnosarcal investment. Hydranths clavate, with a single circlet of filiform tentacles, which surround the base of a conical hypostome. *Gonosome:* Gonophores adelocodonic, borne by the hydranth at the proximal side of the tentacles, or by the creeping stolon." The new deep-sea species, which Allman describes and figures, *Stylactis vermicola*,[4] was found symbiotic on the back of an *Aphrodite*-like Annelid, *Lætmonice producta*, taken in the North Pacific at Station 244, depth 2900 fathoms.

This new deep-sea species, *Stylactis vermicola*, symbiotic with an Annelid, is of particular interest, since it occurs at the same Station (Station 244, depth 2900 fathoms) as our *Stylactis abyssicola*, symbiotic with different Keratosa (Spongelidæ and Stannomidæ). Considering the formation of the gonophores, which spring in this latter directly from the hydrorhiza, and not from the body of the hydranths, I find it

[1] *Ann. and Mag. Nat. Hist.*, ser. 3, vol. xiii. p. 353.
[2] Allman, Monogr. of the Tubularian Hydroids, 1871, p. 302.
[3] Zool. Chall. Exp., pt. lxx. p. 1.
[4] *Loc. cit.*, p. 2, pl. i. fig. 2.

identical with that of *Stylactis vermicola*, but not with that of the three species of true *Stylactis* which originally constituted this genus. I am therefore of the opinion that it would be better, and justified by general systematic principles, to retain the older definition given by Allman in 1871 (p. 302), viz. :—"*Gonosome:* Sporosarc borne on the hydranths at the proximal side of the tentacles," and to separate the symbiotic deep-sea species as a new genus, *Stylactella*, "with gonophores borne on the creeping stolon or the hydrorhiza." The full definition of this genus would then be as follows :—

Stylactella, nov. gen.—Tubulariæ without hydrocaulus, with a reticular hydrorhiza, from which arise single sessile or pedunculate hydranths, and scattered between them single gonophores. Hydranths claviform, naked, with a single circlet of filiform tentacles, which surround the base of a conical hypostome. Gonophores ovate, naked, with a simple central spadix. Chitinous perisarc investing only the tubular branches of the hydrorhiza.

Species of Stylactella.

1. *Stylactella vermicola*, Allman, Report, *loc. cit.*, p. 2, pl. i. fig. 2.—Symbiotic with an Annelid. Station 244; depth, 2900 fathoms.

2. *Stylactella spongicola*, n. sp.—Symbiotic with many Deep-sea Keratosa (Spongelidæ and Stannomidæ). Stations 241, 244, 270 to 274, &c.; depths between 2000 and 2900 fathoms.

3. *Stylactella abyssicola*, n. sp.—Symbiotic with several Deep-sea Keratosa (Spongelidæ and Stannomidæ). Stations 198, 270 to 272, &c.

The genus *Hydranthea*, Hincks, is also similar to our *Stylactella*. Allman, in his Tubularian Monograph (p. 301), places it between *Wrightia* (*Atractylis*) and *Stylactis*. Comparing the figures of his *Hydranthea margarica*, which Hincks gave in 1863,[1] I find it rather different, not only in the formation of the hydranth (with a short hydrocaulus and a double circlet of tentacles), but also in the formation of the gonophores. These are true medusiform sporosacs, with four radial canals in the rudimentary umbrella. The gonophores of *Stylactella*, however, like those of *Stylactis*, are simple club-shaped sacs, with a central blind-canal or spadix, between which and the ectodermal membrane the ova are developed. I am much inclined to regard this formation as a primitive one, not as having arisen from reduced Medusoids (as in the case of *Hydranthea*). I suppose that *Stylactella* (and probably also *Stylactis* and some allied genera) belong to the oldest and most primitive forms of Hydroids, and that their gonophores are not reduced Medusoids, but either simple genital buds, organs of the hydranth (as in *Hydra*), or sexual zooids, separated from the nutritive zooids by division of labour. Perhaps *Stylactella* and the allied genera may represent together a distinct family, Stylactidæ.

[1] *Ann. and Mag. Nat. Hist.*, ser. 3, vol. x. pl. ix. fig. 4.

Stylactella spongicola, n. sp. (Pl. II. figs. 5, 6).

Habitat.—Northern and Central Pacific, symbiotic with Stannomidæ, Spongelidæ, and Psamminidæ; Stations 241, 244, 270, 271, 272, 274; depths between 2300 and 2900 fathoms.

Stylactis with a reticular hydrorhiza, the anastomosing tubes of which are cylindrical and of equal breadth. Hydranths ovate or clavate, springing at short intervals from the hydrorhiza, sessile or very shortly pedunculate, with a single circlet of eight (?) tentacles. Gonophores ovate, twice as large as the hydranths, arising scattered between them from the hydrorhiza.

Stylactella spongicola is by far the most frequent among the Hydroids which live in symbiosis with the Deep-sea Keratosa. It is the usual symbiotic Hydropolyp in all the species of Stannomidæ, and occurs too in some Spongelidæ (*Psammophyllum*, *Cerelasma*) and in some Psamminidæ (*Psammopemma*). Its hydrorhiza traverses the body of these sponges in all directions, and replaces the absent strong spongin-fibres, giving to the sponge a firm support and a distinct form. Since the network of the hydrorhiza is continuous throughout the whole sponge, it reaches in the largest species of *Stannophyllum* (*venosum*) the enormous size of 100 to 200 mm. and more. The polygonal or roundish meshes of the network are of variable diameter, usually between 1 and 0·5 mm., but sometimes they are far larger, 3 to 5 mm. or more, at other times only 0·2 to 0·4 mm. The chitinous tubes of the network are cylindrical, of nearly equal breadth, usually between 0·05 and 0·1 mm., but sometimes 0·12 mm. and more (Pl. II. fig. 6, *h*). The thin, yellowish, chitinous wall is of variable thickness. The entoderm of the hydrorhiza, inside the chitinous tubes, is always dark coloured, greenish brown or yellowish brown.

The hydranths are usually developed in the superficial layers of the network only, and mainly in the distal portion of the sponge. But in many specimens they are difficult to observe, and sometimes I failed to discover them at all. They are most easily examined in those Stannomidæ in which the skeleton is for the most part composed of Globigerina ooze. After having dissolved the calcareous matter by hydrochloric acid, there remains the transparent and colourless mesoderm of the sponge, in which the dark network of the hydrorhiza is easily seen (Pl. II. fig. 5).

The hydranths of *Stylactella spongicola* are ovate or club-shaped, and spring at irregular intervals directly from the branches of the hydrorhiza. They are very small, only 0·2 to 0·3 mm. in diameter, whilst the hydranths of *Stylactis vermicola* (Allman, *loc. cit.*) are ten times as large. The small basal pedicle, which is very distinct in this latter, invested with a chitinous perisarc ("rudimental stem," Allman), is wanting in the former species. The small claviform or oviform hydranths exhibit at the distal

end a rounded or conical hypostome, and beyond it a circlet of a few short simple tentacles; their number seems to be usually (or always?) eight. The tentacles are usually highly contracted and turned inwards, rarely distinctly protruded (fig. 6, *ij*).

The gonophores are wanting in the great majority of the specimens examined. They were, however, very distinct in a few specimens which were found in *Stannophyllum globigerinum* and in *Stannarium alatum*. They are shortly pedunculate, of the same ovate or club-shaped form as the hydranths, but twice or three times as long and broad, without tentacles, and represent sporosacs, which in a few cases were distinctly filled with eggs (fig. 6, *e*). The entoderm of the gonophores and hydranths exhibits the same dark brown or greenish colour as that of the hydrorhiza.

Stylactella abyssicola, n. sp. (Pl. II. fig. 7).

Habitat.—Northern and Central Pacific; symbiotic with Stannomidæ and Spongelidæ: Stations 244, 271, 272; depths between 2300 and 2900 fathoms.

Stylactis with a reticular hydrorhiza, the anastomosing tubes of which are of variable breadth, fusiform dilatations alternating with narrower cylindrical portions. Hydranths ovate, pedunculate, springing at short intervals from the hydrorhiza, provided with a simple circlet of twelve to sixteen tentacles. Gonophores of about the same size as the hydranths, arising scattered between them from the hydrorhiza.

Stylactella abyssicola is much less abundant than the preceding closely-allied species; it occurs in several specimens of *Psammophyllum* and *Stannophyllum*, taken at Stations 244, 271, and 272. It is easily distinguished from the smaller *Stylactella spongicola* by the larger size of all the parts, and the irregular formation of the tubes of the hydrorhiza. These are not cylindrical and of equal breadth, but exhibit irregular fusiform dilatations (often a single one between every two hydranths). Often also the nodal points of the anastomosing tubes exhibit triangular dilatations. The diameter of the tubes is usually between 0·2 and 0·3 mm., twice or thrice as large as in *Stylactella spongicola*, and the chitinous perisarc is thicker than in the latter; the network of the hydrorhiza is looser and its meshes larger.

The hydranths arise from the hydrorhiza with short peduncles, usually of their own length; they are club-shaped or ovate, 0·5 to 0·6 mm. in diameter, and bear beyond the shortly conical hypostome a single circlet of tentacles (about ten or twelve to sixteen). I was, however, able in a few cases only to recognise the form of the hydranths distinctly (fig. 7, *ij*). The same must be said of the gonophores, which are scarcely larger than the hydranths, of the same form, but without tentacles (fig. 7, *g*), springing from the hydrorhiza (*h*) scattered between the hydranths.

Classification of Sponges.

The principles of classification have assumed in modern zoology a general importance previously unknown, since we maintain that these principles are essentially phylogenetical, that morphological relation in a certain sense is historical, and that a true natural system approaches to the hypothetical pedigree of the related forms. The class of sponges possesses in this respect a particular interest, because they are the lowermost among the Metazoa, the simplest in organisation, and the most variable as regards constancy of species. Led by this conviction, I began in 1867 my researches on the Calcispongiæ, the results of which were published in 1872 in my Monograph of this order.

The general principles of classification there given are in accordance with those which have been employed in three excellent Monographs among the five Reports hitherto published on the sponges collected by the Challenger Expedition. W. J. Sollas in his Report on the Tetractinellida,[1] F. E. Schulze in his Report on the Hexactinellida,[2] and S. O. Ridley and A. Dendy in their Report on the Monaxonida,[3] have expressed opinions and followed principles in the classification of the Spongiæ which are essentially the same as my own. But the same cannot be said of two other reports on sponges belonging to this series, viz., those which Dr. Poléjaeff has published on the Calcarea[4] and on the Keratosa.[5] Since my own researches concerned just these two groups, and since my general statements are severely attacked by Dr. Poléjaeff, I may be permitted here to add some remarks on his opposing views, and to explain the contradictions in our systematical aims.

Poléjaeff has explained his systematical principles not only in the two Reports above mentioned, but also in the general account of his chief results communicated in the Narrative of the Cruise of H.M.S. Challenger.[6] His first and foremost principle is, that a natural classification of the sponges, hitherto wanting, can only be reached by comparative physiology. "So long as spongiology will not attach due influence to comparative physiology in its systematic proceedings, no hopes can be entertained of a natural arrangement of the sponges."[7] The most important part of a natural systematic classification, according to Poléjaeff, consists in the task of proving actually which of the so-called genera and subgenera "are really to be regarded as subgenera (*i.e.*, groups which, although connected by numerous intermediate stages with their systematic neighbours, still present in their organisation a new principle fit for a further development) and not as species and even varieties. This latter question is to be decided (perhaps exclusively) by the methods of comparative physiology."[8] Poléjaeff also

[1] Zool. Chall. Exp., pt. lxiii. vol. xxv. p. cv.
[2] Zool. Chall. Exp., pt. liii. vol. xxi. p. 485.
[3] Zool. Chall. Exp., pt. lix. vol. xx. p. 53.
[4] Zool. Chall. Exp., pt. xxiv. vol. viii.
[5] Zool. Chall. Exp., pt. xxxi. vol. xi.
[6] Narr. Chall. Exp., vol. i. p. 639.
[7] *Loc. cit.*, p. 643.
[8] *Loc. cit.*, p. 644.

concludes his Report on the Keratosa with general considerations on the systematic importance of comparative physiology, which, according to him, shall solve the difficult problems that no morphological science, neither comparative anatomy nor comparative ontogeny, may be able to solve.

My own systematic principles, based on classificatory work of thirty years, and practically employed in my General Morphology (1866), as well as in my Monographs of the Radiolaria, Calcispongiæ, Medusæ, and Siphonophoræ, start from quite an opposite point of view. My firm conviction is, that every systematic task can be solved only by morphological, not by physiological work. I cannot find, in the immense systematic literature of zoology and botany, a single work in which any important progress has been made by the help of comparative physiology; I cannot even understand in what possible way this science should be useful. All classificatory works, clearing our views on the natural system of major or minor groups, are based only upon morphological researches either of comparative anatomy (in the widest sense) or of comparative ontogeny and palæontology. Morphology and physiology, the two main branches of biological science, are of equal value and equal importance, but their methods and aims are totally different, and in systematic work, in the distinction and phylogenetic arrangement of forms, morphology alone is applicable, not physiology. Dr. Poléjaeff himself, although so emphatically praising the latter, has in his classification employed only the former; he has not demonstrated the way in which classification shall be elucidated by comparative physiology.

The second important point in which my systematic views are quite opposed to those of Dr. Poléjaeff, is the true meaning and the proper signification of the systematic categories, or of the larger and smaller groups of forms, which are distinguished in each system as classes, orders, families, genera, species, varieties, &c. Two different and opposite conceptions are possible in this respect: either all these categories are artificial and of only relative value, divisions produced by the logical mind of the systematic naturalist, or they are all natural and possess an absolute character, founded on their morphological differences and justifying their absolute distinction. We may briefly call this latter the dogmatic conception, the former the critical conception of the systematic categories.

The dogmatic conception, supported by Dr. Poléjaeff, has been explained in the most ingenious manner by Louis Agassiz, in his well-known essay on classification (1859). He undertook the task of giving an absolute definition to each of the systematic categories, and to prove that they are distinct not only in a relative and quantitative respect, but also in an absolute and qualitative respect. I have given a careful critical analysis of these views in chapter xxiv. of my General Morphology.[1] I have stated there that each absolute definition of any category, in the sense of L. Agassiz, is perfectly

[1] Generelle Morphologie, vol. ii. pp. 374–402.

artificial and in no way tenable. I quite agree with Jean Lamarck, who has entitled the first chapter of his classical Philosophie Zoologique (1809):—"Des parties de l'art dans les productions de la nature"; he has clearly proved that all our systematic categories, classes and orders, no less than the genera and species, are artificial products of the human mind, and that they all possess only a relative, not an absolute, character. The theory of selection, given half a century afterwards by the immortal Charles Darwin, explains how all these categories have arisen, and shows that natural classification can only be phylogenetical, and that all apparently "good species" were originally "bad species."

Special diligence has been displayed by Poléjaeff in giving an absolute definition of the category of genus. According to him, "generic unity serves as a firm basis, which has been wanting in descriptive zoology since the mutability of species was actually proved."[1] He regards "the generic character to be a character of sufficient constancy, and together with this, allowing numerous modifications either in the direction of a further development or in the direction of different variations."[2] But may we not say the same of the family? the same of the species? the same of the variety? This dogmatic definition, and also any other attempt to characterise any category of the system by an absolute definition, are, in my opinion, quite untenable and worthless. I think I have proved this in chapter xxiv. of my General Morphology. Genera are artificial conceptions in the same way as species; varieties are incipient species, species incipient genera.

Poléjaeff gives in chapter ii. of his Report on the Keratosa a criticism of the genera, and commences it with an enumeration of the three conditions which Nägeli holds indispensable for the absolute distinction of genera.[3] But what Nägeli demands for the allied species of one genus may be demanded for the genera of one family, the same for the families of one order, the same for the varieties of one species. Poléjaeff adopts the opinion of Nägeli, that "the existence of an absolute distinction of genera is indispensable,"[4] and he undertakes to give such an absolute distinction. In my opinion, these genera are no more and no less artificial than all other genera. The history of systematic classification shows us that the absolute distinction of genera is quite impossible, and that the progress of one century has been sufficient to dissolve the definitions and the conceptions of nearly all the older genera, and to replace them by a larger number of smaller genera; the latter, of course, must increase in the same degree as the specialisation of our knowledge and the specification of minor morphological differences.

Having stated that the first principles of classification employed by Poléjaeff and by myself are quite contrary to each other, and that we have adopted quite opposite general views, it will be understood that as a natural consequence this diligent Russian author severely attacks the less important parts of my Monograph of Calcispongiæ.

[1] Zool. Chall. Exp., pt. xxxi. p. 82.
[2] Narr. Chall. Exp., vol. i. p. 644.
[3] *Loc. cit.*, p. 21.
[4] Narr. Chall. Exp., vol. i. p. 645.

This is not the place to answer his objections; I may only remark, that he has not taken into account the main intention of my classificatory essay, which was to prove analytically the theory of descent, and to prove that so-called "bonæ species" do not exist in nature, that they are all originally "bad species." I have noted this principal intention in the preface to my Monograph of Calcispongiæ (pp. xi, xii), and explained it in the second part of the fourth chapter (Phylogeny, pp. 340–360). A natural consequence of my phylogenetic conviction is the opinion that "natural species" do not exist, and therefore the 21 genera and 111 species which I have distinguished in my "natural system" can possess only a relative value. They are, indeed, more natural than those of the older artificial system. Poléjaeff, always looking for absolute distinction, must, of course, reject them. But his own distinctions are also more or less artificial, and exposed to the same general objections as all others.

Curiously enough, Poléjaeff says in the Narrative,[1] that "the whole Report on the Keratosa is almost exclusively of a critical character." My own view, based upon opposite principles, is that his Reports are more dogmatical than critical. For example, I must regard it as perfectly dogmatical when Poléjaeff unites all the Keratosa in a single family and all the Asconidæ in a single genus. What advantage is got by this summary blending? It would be scarcely less dogmatical to unite all the Keratosa in a single genus, or all the sponges in a single family. Poléjaeff strongly blames the *circulus vitrosus* which most authors follow in distinguishing genera and families among the sponges.[2] In my own opinion, his whole systematic work turns in a large *circulus vitrosus*. It is based upon dogmatic convictions which are quite incompatible with our modern phylogenetical views and with the first principles of the theory of descent.

Relation of the Keratosa to the other Sponges.

The new forms of so-called Keratosa (or Ceratina) which are described in this Report, and which inhabit the abyssal regions of the deep sea, seem to throw a new light on this remarkable group of sponges, and to modify somewhat our views on their relations to the other Porifera. The general opinion of most modern spongiologists (maintained by F. E. Schulze, Lendenfeld, Vosmaer, Sollas, and others) is, that the horny sponges or Keratosa have descended from Silicosa, or from sponges which possessed siliceous spicules. The uninterrupted chain which connects certain Keratosa with certain Silicosa is the mainstay of this opinion. I must confess that this phylogenetical hypothesis, though based on many acceptable arguments, seems to me by no means to be decidedly demonstrated. The new Keratosa here described present several great difficulties to its acceptance. It seems to me very improbable that all these characteristic horny sponges of the deep sea (and especially the cannocœlous Ammoconidæ) are degenerate Silicosa

[1] *Loc. cit.*, p. 645.

[2] Zool. Chall. Exp., pt. xxxi. p. 83.

which have lost the siliceous spicules. In my opinion, the common ancestral group of all sponges (provided that the whole class is monophyletic) has been skeletonless, and the various main groups (subclasses or orders) descending from it have acquired the different skeletal forms in different ways polyphyletically. This does not exclude the possibility that in some skeletonless sponges the want of a proper skeleton is secondary, produced by reduction.

For the sake of brevity and clearness I will here call the hypothetical common ancestral group, in which originally no skeleton was formed, Archispongiæ. To this primordial group may perhaps belong some Myxospongiæ (Halisarcidæ, Chondrosidæ) and some Psammospongiæ (Ammoconidæ, Psamminidæ). From the same common ancestral group may have arisen, as independent main branches, on one side the Calcispongiæ, on the other side a part of the true Keratosa (not descended from Silicosa), and further the Demospongiæ (Monaxonida and Tetractinellida) and the Hyalospongiæ (Hexactinellida). It is quite possible that a horny skeleton, produced by the formation of spongin-fibres, has arisen polyphyletically, independently in different groups of sponges. The now prevailing opinion of their monophyletic origin seems to me not very probable.

The nature and origin of the horny skeleton is an important point in these phylogenetical problems. In my opinion, the spongin-skeleton must not be regarded as a formation of the same order and value as the calcareous skeleton of the Calcispongiæ, or the siliceous skeleton of the Silicosa. Regarded from a general histological point of view, the horny tissue of the sponges seems to present many analogies in form and development to the elastic tissue in the higher Metazoa. The different forms of thin fibrillæ and strong fibres, simple and branched fibrillæ, isolated and reticulated fibres, bundles and networks of fibrillæ, which are found among the numerous modifications of the elastic tissue, and which arise in the maltha or the ground-mass of the connective tissue, occur also in the horny fibrous tissue of the sponges. The chemical nature is little different, and even the origin may often be similar. The strong fibres of many Keratosa are produced by series of associated spongoblasts (F. E. Schulze), but the fine fibrillæ of the Stannomidæ and the spongin-capsules and lamellæ of *Cerelasma* are certainly formed in another way. Perhaps each fine fibrilla of the Stannomidæ is the filiform product of a wandering amœbocyte, in a similar way as a dentin-fibrilla is secreted from an odontoblast. But it may also be that these and similar spongin-fibrillæ are produced by a chemical and physical alteration of the ground-mass, without the direct action of a cell, in a similar way as is the case in the fibrous cartilage.

Comparing the horny skeletons in the new Keratosa here described (especially the Stannomidæ), and in the various groups of the so-called Cornacuspongiæ, it seems to me very probable that horny fibres, as strengthenings of the maltha, have arisen in different groups of Keratosa and of Silicosa, independently one from another; it is even very probable that the fossil Pharetrones (Zittel), that remarkable group of Calcispongiæ which

was extinct in the cretaceous period, possessed a similar fibrous horny skeleton as in many Halichondriæ.

Greater difficulties still arise against the modern views on the phylogeny of sponges when we consider the different forms of the canal-system. The two main forms of it, as now generally considered, are the tubular form of the Asconal-type (Asconidæ) and the vesicular form of the Leuconal-type (and the allied Syconal and Aplysinal types). The latter, being the more complex, must have originally risen from the former, in which is found the simplest architype of all, the *Olynthus*, closely allied to the *Gastræa*. The great phylogenetical importance of this archisponge, first pointed out in my Monograph of the Calcispongiæ, is now generally accepted. But the *Olynthus* there described, and the allied Asconidæ, possess a calcareous skeleton; they must have been derived from an older simple sponge of the same type, which was as yet skeletonless. A slight modification of this hypothetical *Archolynthus* seems to be our interesting *Ammolynthus*. This typical form and the other closely-allied Ammoconidæ (*Ammosolenia*, *Ammoconia*) supply a new and strong argument in favour of the opinion that the vesicular sponges (with flagellated chambers) originally descended from tubular sponges (with tubular flagellated epithelium); we may call the latter (with canal-system of the Asconal-type) Protospongiæ, the former (with canal-system of the Leuconal-type) Metaspongiæ. Starting from this point of view, we may arrive at the following classification of the sponges:—

First Class. PROTOSPONGIÆ,

With tubular canal-system (Asconal-type).

Order I. AMMOCONIDÆ (Malthosa) = CANNOCŒLA.

Order II. ASCONIDÆ (Calcarosa) = HOMOCŒLA.

Second Class. METASPONGIÆ,

With vesicular canal-system (Leuconal, Syconal, or Aplysinal type).

Order III. MALTHOSPONGIÆ (originally skeletonless Keratosa) = DOMATOCŒLA (Psamminidæ, and perhaps many Ceratinæ).

Order IV. DEMOSPONGIÆ (Sollas, Zool. Chall. Exp., pt. lxiii. p. xcviii).

Order V. HYALOSPONGIÆ (Hexactinellidæ).

Order VI. CALCISPONGIÆ (Syconidæ, Leuconidæ, Tichonidæ, Pharetronidæ, excluding Asconidæ) = HETEROCŒLA.

We may have another classification of the main groups of sponges if we consider as the first principles of classification, not those important differences of the tubular and vesicular canal-system (corresponding to the structures of the tubular and vesicular glands), but the differences in the materials of the skeleton. The great value of these skeletal differences has been acknowledged since Grant's time, and employed in various ways by later authors up to this time, but it seems to me that no single author has pointed out the important difference, phylogenetically, between a primary want of the skeleton and a secondary one (by reduction); further, all authors of recent time, in my opinion, have followed too far the monophyletic way (especially in judging of the Keratosa), whilst in animals of such simple structure and low degree of organisation polyphyletic hypotheses often approach nearer to the truth.

Particular attention should be paid in this respect to the Psammospongiæ, under which name I comprise those remarkable so-called Keratosa in which no trace of spongin is found, but in which the whole skeleton consists only of agglutinated xenophya, crowded in the maltha, and is therefore a false or pseudo-skeleton. These Psammospongiæ, or pure arenaceous sponges, are represented in the Challenger collection by the Ammoconidæ (Pl. VIII.) and Psamminidæ (Pl. VII.) described above, with six genera and twelve species of peculiar interest. Most authors, following the presently accepted views, would regard these Psammospongiæ as most reduced forms, derived from Silicosa, which have lost the siliceous spicules as well as the spongin-skeleton. In my opinion, it is more natural to regard these low forms as primitive ones, as Archispongiæ, which begin the skeleton formation by taking up xenophya.

Accepting this theory, we may even assume that the double formation of the mineral skeleton of sponges, the calcareous and the siliceous, has a causal relation to the double composition of the deep-sea ooze, from which the eldest Psammospongiæ have taken their skeleton materials, the calcareous Globigerina ooze and the siliceous Radiolarian ooze. The descendants of the oldest Archispongiæ (which certainly were skeletonless) began to take up deep-sea ooze from the bottom, and to crowd this supporting and protecting material in their maltha. By and by the mesodermal tissue was adapted to dissolve certain quantities of those two mineral bodies, and afterwards a certain portion of the dissolved mineral matter contained in the maltha was secreted in the form of spicules. This secretion may have been perfectly independent from the formation of spongin-fibres in the maltha. In such a manner the oldest Calcispongiæ (Asconidæ) may have descended perhaps from Psammospongiæ, which had taken up Globigerina ooze (*e.g.*, *Ammolynthus haliphysema*, Pl. VIII. figs. 2–4), and in a similar manner the Silicispongiæ (perhaps polyphyletically in several independent branches) may have arisen from the oldest Psammospongiæ, which had taken up Radiolarian ooze (*e.g.*, *Ammolynthus prototypus*, Pl. VIII. fig. 1).

Starting from this standpoint, we may accept as provisional the following classification

of sponges. Certainly it is widely remote from being a true natural system, but the same must be said of all other attempts at classification of sponges up to the most recent times. All spongiologists who will judge critically, and compare the divisions not dogmatically (like Poléjaeff), will agree with this my view.

Artificial Classification of Sponges founded on the Skeletal Structure.

First Class. MALTHOSPONGIÆ (or MALTHOSA).

Porifera which possess no true mineral skeleton (composed of calcareous or siliceous spicules), with or without spongin-skeleton, with or without pseudo-skeleton (composed of xenophya).

Order I. MYXOSPONGIÆ.—Without spongin-skeleton and without pseudo-skeleton (Halisarcidæ, Chondrosidæ).

Order II. PSAMMOSPONGIÆ.—Without spongin-skeleton, but with a pseudo-skeleton composed of xenophya (Ammoconidæ, Psamminidæ).

Order III. CERASPONGIÆ.—With a true spongin-skeleton, with or without xenophya (Spongelidæ, Stannomidæ, Darwinellidæ, Euspongidæ, Aplysinidæ).

Second Class. SILICISPONGIÆ (or SILICOSA).

Porifera which produce a true siliceous skeleton, composed of siliceous spicules secreted by the sponge itself, with or without spongin-skeleton.

Order IV. DEMOSPONGIÆ (Monaxonidæ and Tetractinellidæ).—With simple (monaxial) or four-rayed (tetraxial) siliceous spicules, with or without spongin-skeleton.

Order V. HYALOSPONGIÆ (Hexactinellidæ).—With six-rayed and triaxial spicules, without spongin-skeleton.

Third Class. CALCISPONGIÆ (or CALCAROSA).

Porifera which produce a true calcareous skeleton, composed of calcareous spicules secreted by the sponge itself, with or without spongin-skeleton.

Order VI. ASCOSPONGIÆ (Asconidæ or Homocœlæ).—Calcisponges without spongin-skeleton, with tubular canal-system.

Order VII. Leucospongiæ (Syconidæ, Leuconidæ, and Tichonidæ).—Calcisponges without spongin-skeleton, with vesicular canal-system.

Order VIII. Pharospongiæ (Pharetronidæ).—Calcisponges with a fibrous spongin-skeleton, with vesicular canal-system.

Position of the Sponges in the Animal Kingdom.

The important question of the natural affinities of the sponges and of their position in the animal kingdom has been fully discussed in the former Reports of this series already quoted, and especially in the excellent Report of Sollas on the Tetractinellida.[1] Agreeing in general with the deductions of Sollas, as well as with his general conceptions of the sponge organisation, it seems to me not necessary to separate the Spongiæ from the other Metazoa. The fact that the sponges develop from a true Gastrula, and their tissues from two primary germ-layers, as in all other Metazoa, seems to prove the validity of their position within this kingdom. This position is mainly maintained by Lendenfeld in his works above quoted (1886). The same opinion is confirmed afresh if we look upon the flagellated chamber as the primitive individual, and as homologous with a Gastræa on the one hand and with a simple Hydroid on the other. I agree with Sollas that the sponges form a separate phylum within the sub-kingdom Cœlenterata, but the distance between them and the Cnidaria (especially the Hydroida) is not greater than that between the Cnidaria and the Platoda. The general results of this Report on the Deep-sea Keratosa seem to confirm this opinion.

The position of the sponges in the animal kingdom (as a separate phylum of the Cœlenterata), which in the present state of our daily increasing knowledge seems to be the most natural, will be best understood from the following synopsis of the Metazoa, which I have employed in my lectures during recent years :—

Systematical Synopsis of the Main Branches, Phyla, and Classes of the Metazoa.

A. First main branch of the Metazoa.

Cœlenteria (Cœlenterata vel Zoophyta).

Phylum I. Gastræada.

Classes : 1. Physemaria ; 2. Cyemaria (Orthonectidæ, Dicyemidæ).

[1] Zool. Chall. Exp., pt. lxiii. vol. xxv. p. cxii.

Phylum II. Spongiæ (Porifera).

Classes: 1. Malthospongiæ; 2. Silicispongiæ; 3. Calcispongiæ [or perhaps better, 1. Protospongiæ (Tubulosæ); 2. Metaspongiæ (Vesiculosæ)].

Phylum III. Cnidaria (Acalephæ).

IIIa. Subphylum 1. Hydrozoa.

Classes: 1. Hydropolypi; 2. Hydromedusæ (Craspedotæ); 3. Siphonophoræ.

IIIb. Subphylum 2. Scyphozoa.

Classes: 4. Scyphopolypi; 5. Anthozoa (Corolla); 6. Scyphomedusæ (Acraspedæ).

Phylum IV. Platoda (Plathelminthes).

Classes: 1. Turbellaria; 2. Trematoda; 3. Cestoda; 4. Ctenophora (?).

B. Second main branch of the Metazoa.

Cœlomaria (Cœlomata vel Bilateria).

Phylum V. Helminthes (Vermes).

Va. Subphylum 1. Archelminthes.

Classes: 1. Trochozoa; 2. Rotatoria.

Vb. Subphylum 2. Strongylaria.

Classes: 3. Nematoda; 4. Acanthocephala; 5. Chætognathi.

Vc. Subphylum 3. Rhynchocœla.

Classes: 6. Nemertina; 7. Enteropneusta.

Vd. Subphylum 4. Prosopygia.

Classes: 8. Bryozoa; 9. Phoronida; 10. Brachiopoda.

Phylum VI. Mollusca.

VIa. Subphylum 1. Cochlides.

Classes: 1. Placophora; 2. Gastropoda; 3. Scaphopoda; 4. Pteropoda.

VIb. Subphylum 2. Conchades.

Class: 5. Acephala.

VIc. Subphylum 3. Teuthodes.

Class: 6. Cephalopoda.

Phylum VII. Echinoderma.

VIIa. Subphylum 1. Thecostellæ.

Classes: 1. Holothuriæ; 2. Echinida.

VIIb. Subphylum 2. Pectostellæ.

Classes: 3. Cystidea; 4. Crinoidea; 5. Blastoidea.

VIIc. Subphylum 3. Anthostellæ.

Classes: 6. Ophiuræ; 7. Asterida.

Phylum VIII. Articulata.

VIIIa. Subphylum 1. Annelida.

Classes: 1. Hirudinea; 2. Chætopoda; 3. Gephyrea; 4. Myzostomida.

VIIIb. Subphylum 2. Crustacea.

Classes: 4. Caridonia (Carides); 5. Aspidonia (Merostomata).

VIIIc. Subphylum 3. Tracheata.

Classes: 6. Onychophora; 7. Myriapoda; 8. Arachnida; 9. Insecta.

Phylum IX. Chordonia.

IXa. Subphylum 1. Tunicata.

Classes: 1. Copelata; 2. Ascidiæ; 3. Thaliæ.

IXb. Subphylum 2. Vertebrata.

Classes: 1. Acrania; 2. Cyclostoma; 3. Pisces; 4. Dipneusta; 5. Amphibia; 6. Reptilia; 7. Aves; 8. Mammalia.

PLATE I.

Family STANNOMIDÆ.

Genus *Stannophyllum.*

PLATE I.

Stannophyllum.

Figs. 1A–1C. *Stannophyllum zonarium*, n. sp. (p. 62).

Figs. 1A, 1B. Two complete sepcimens, ... nat. size

Fig. 1C. A small portion of the surface; magnified.

Figs. 2A–2C. *Stannophyllum radiolarium*, n. sp. (p. 65).

Figs. 2A, 2B. Two complete specimens, ... nat. size

Fig. 2C. A small portion of the surface; magnified.

Figs. 3A, 3B. *Stannophyllum pertusum*, n. sp. (p. 65).

Fig. 3A. Complete specimen, ... nat. size

Fig. 3B. A small portion of the surface; magnified.

Fig. 4. *Stannophyllum venosum*, n. sp. (p. 67).

Fig. 4. Complete specimen, ... half nat. size

Fig. 5A–5C. *Stannophyllum globigerinum*, n. sp. (p. 68).

Figs. 5A, 5B. Two complete specimens, 5B having a facial branch (transition to *Stannarium*), ... nat. size

Fig. 5C. A small portion of the surface; magnified.

E. Haeckel and A. Giltsch Del.

A. Giltsch Jena Lithogr

1-5. STANNOPHYLLUM, 1. S. ZONARIUM, 2. S. RADIOLARIUM,
3. S. PERTUSUM, 4. S. VENOSUM, 5. S. GLOBIGERINUM,

PLATE II.

Family STANNOMIDÆ.

Genus *Stannophyllum.*

PLATE II.

Stannophyllum.

Figs. 1–4. *Stannophyllum zonarium*, n. sp. (p. 62).

Diam.

Fig. 1. A small portion of the dermal surface, with a single pore (*p*), . × 70

Fig. 2. Another small portion of the dermal surface, more highly magnified, with three pores (*p*). *m*, maltha (ground-mass of the mesoderm); *f*, spongin-fibrillæ; *r*, Radiolarian shells, ... × 200

Fig. 3. Section through a large subdermal cavity. Characters as in fig. 2. *h*, symbiotic hydrorhiza, ... × 70

Fig. 4. View of the distal margin of the flabelliform sponge, with the irregular lacunar cavities of the canal system, ... × 30

Figs. 5, 6. *Stylactella spongicola*, n. sp. (Tubularian Hydroid, p. 80).

Fig. 5. Network of the symbiotic hydrorhiza, creeping below the dermal membrane of *Stannophyllum globigerinum*, with numerous well preserved hydranths, ... × 30

Fig. 6. Tubularian polyp-stock symbiotic with *Stannophyllum globigerinum*. *h*, hydrorhiza; *g*, gonophores; *e*, eggs; *v*, germinal vesicles; *ÿ*, hydranths, ... × 70

Fig. 7. *Stylactella abyssicola*, n. sp. (p. 81).

Fig. 7. Tubularian polyp-stock symbiotic with *Psammophyllum annectens* (see p. 53). Characters as in fig. 6; *s*, spermarium, . . × 70

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A. Giltsch Jena Lith.

1-4. STANNOPHYLLUM ZONARIUM.

5-7. STYLACTELLA, 5, 6. S. SPONGICOLA, 7. S. ABYSSICOLA.

PLATE III.

Family STANNOMIDÆ.

Genera *Stannoma*, *Stannarium*.

PLATE III.

Figs. 1–4. *Stannoma dendroides*, n. sp. (p. 72).

Diam.

Fig. 1. Complete specimen, ... × 2

Fig. 2. Transverse section through a branch. *f*, spongin-fibrillæ; *r*, Radiolarian shells; *h*, tubular portions of the reticular hydrorhiza of the symbiotic Hydroid (*Stylactella*), ... × 40

Fig. 3. A small portion of the same transverse section (fig. 2); more highly magnified. Characters as in fig. 2, ... × 150

Fig. 4. Surface of a branch. Characters as in fig. 2, ... × 70

Fig. 5. *Stannoma coralloides*, n. sp. (p. 73) .

Fig. 5. Complete specimen, ... × 3

Figs. 6–9. *Stannarium alatum*, n. sp. (p. 70).

Figs. 6, 7. Lateral views, from different sides, ... × 1·5

Fig. 8. Apical view, ... × 1·5

Fig. 9. A bunch of spongin-fibrillæ, ... × 400

Figs. 10–14. *Stannarium concretum*, n. sp. (p. 71).

Figs. 10–12. Small specimen, the xenophya of which are principally Radiolarian shells, ... × 1·5

Fig. 10, lateral view; fig. 11, apical view; fig. 12, basal view.

Figs. 13, 14. Larger specimen (of a softer consistency than the specimen represented in figs. 10–12), the xenophya of which are principally fragments of *Globigerina* shells, ... × 1·5

Fig. 13, apical view; fig. 14, lateral view.

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A. Giltsch, Jena, Lithogr.

1-5. STANNOMA, 1-4. S. DENDROIDES, 5. S. CORALLOIDES,
6-14. STANNARIUM, 6-9. S. ALATUM, 10-14. S. CONCRETUM.

PLATE IV.

Family SPONGELIDÆ.

Genus *Psammophyllum.*

PLATE IV.

Psammophyllum.

Figs. 1–4. *Psammophyllum annectens*, n. sp. (p. 52).

Diam.

Fig. 1. A complete flabelliform specimen, ... nat. size

Fig. 2. Portion of a section through the same. *f*, network of spongin-fibrillæ; *r*, Radiolarian shells, ... × 300

Fig. 3. Some spongin-fibrillæ, including Radiolarian shells, . . . × 400

Fig. 4. Chitinous tubes of the hydrorhiza of a symbiotic Hydroid, with annular constrictions (*Eudendrium?*), ... × 100

Figs. 5–8. *Psammophyllum flustraceum*, n. sp. (p. 51).

Fig. 5. A complete flabelliform specimen, ... nat. size

Fig. 6. Portion of a section through the same. *f*, network of spongin-fibrillæ; *r*, Radiolarian shells and sponge spicules, . . × 300

Fig. 7. Portion of the surface of fig. 5, from its distal part, exhibiting three concentric zones, with the dermal pores (*p*), and the larger openings (oscula, *o*) at the thickened proximal margin of each zone, . × 4

Fig. 8. A small portion of the outermost distal zone; more highly magnified. The surface exhibits the smaller openings (pores), and scattered larger openings (oscula, *o*) at the thickened proximal margin of the zone, ... × 12

Fig. 9. *Halisiphonia spongicola*, n. sp. (p. 77).

Fig. 9. Hydroid living in symbiosis with *Psammophyllum flustraceum*. *h*, the reticular hydrorhiza; *g*, gonangia; *p*, hydrothecæ, . . × 20

F. Haeckel and A. Gültsch Del.

A. Gültsch Jena Lithogr.

1-8. PSAMMOPHYLLUM. 1-4. P. ANNECTENS. 5-8. P. FLUSTRACEUM.

9. HALISIPHONIA SPONGICOLA.

PLATE V.

Family SPONGELIDÆ.

Genus *Psammophyllum.*

PLATE V.

Psammophyllum.

Figs. 1–4. *Psammophyllum reticulatum*, n. sp. (p. 50).

Diam.

Fig. 1. A young specimen. The entire parenchyma of the flabelliform sponge is traversed by a coarse network of brown cylindrical tubes, the hydrorhiza of a symbiotic Hydroid (*Stylactella?*). The meshes of this coarse network are filled up by a very fine and delicate network, composed of branching and anastomosing spongin-fibrillæ, which enclose and connect foreign bodies, mainly siliceous spicules of different sponges, ... × 10

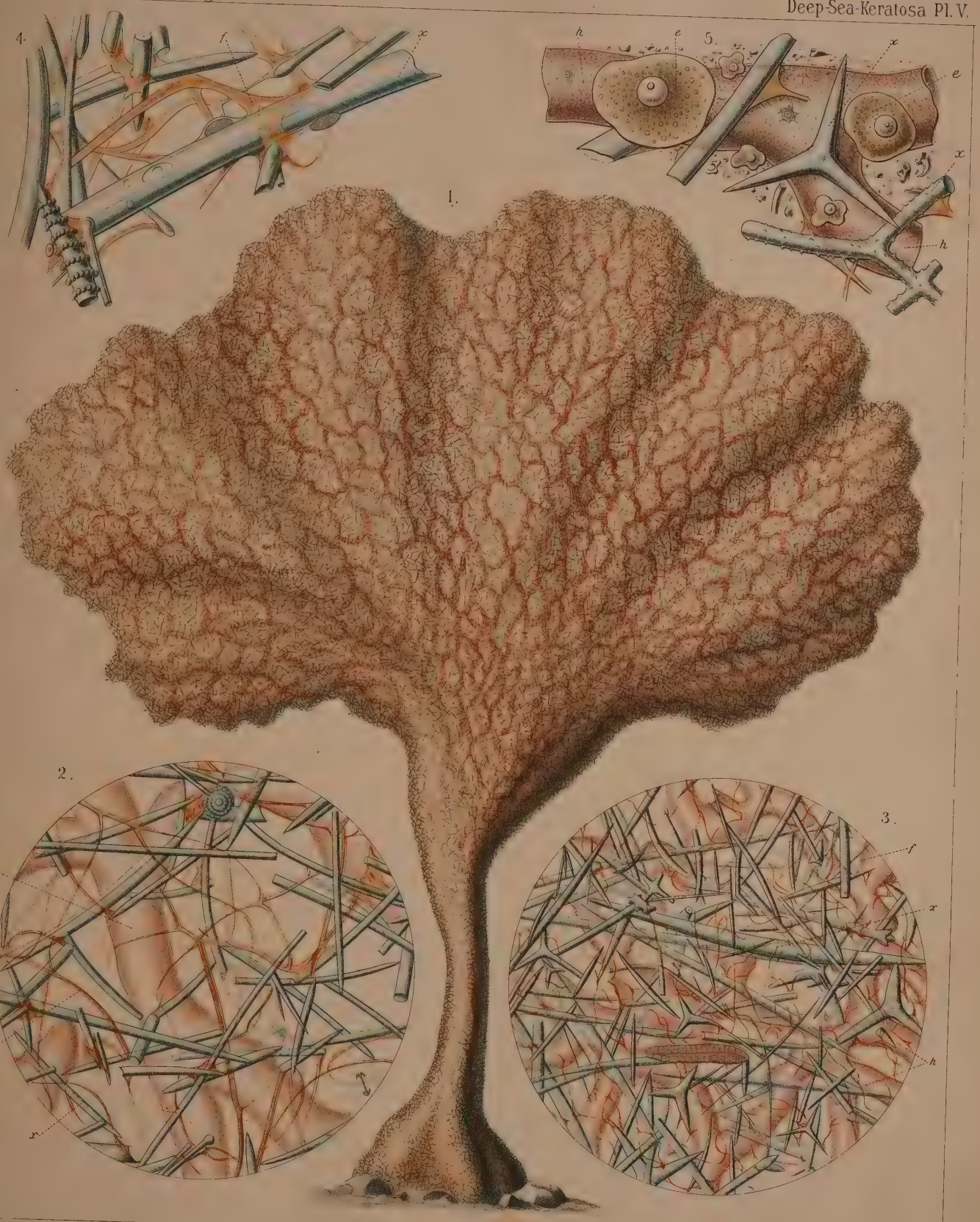
Fig. 2. A small portion of the skeleton of the flabelliform sponge. Between the thick brown tubes of the symbiotic Hydroid (*h*), the fine network of the yellow spongin-fibrillæ (*f*), and numerous scattered xenophya (*x*) are visible, ... × 100

Fig. 3. A small portion of the same; less highly magnified. Characters as in fig. 2, ... × 50

Fig. 4. A few xenophya (sponge spicules and Radiolarian fragments) cemented together by the scanty yellow spongin-fibres (*f*), . . . × 300

Fig. 5. *Psammophyllum flustraceum*, n. sp. (p. 51.)

Fig. 5. A forked chitinous tube of a symbiotic Hydroid (*h*); the epithelium on its inside is exceptionally well preserved. In the surrounding maltha of the sponge are visible single amœboid cells and eggs (*e*), and between them are scattered a few xenophya (*x*), and the connecting yellow spongin-fibres, ... × 200



F. Haeckel and A. Giltsch Del.

PSAMMOPHYLLUM RETICULATUM.

A. Giltsch Jena Lithogr.

PLATE VI.

Family SPONGELIDÆ.

Genus *Cerelasma.*

PLATE VI.

Cerelasma.

Figs. 1–5. *Cerelasma gyrosphæra*, n. sp. (p. 46).

Diam.

Fig. 1. A complete spherical specimen of the sponge, . . . nat. size

Fig. 2. A small portion of a transverse section through a branch. *f*, spongin-lamellæ; *x*, pseudo-skeleton composed of xenophya; *h*, greenish hydrorhiza of the symbiotic Hydroid, ... × 50

Fig. 3. A small portion of the section, fig. 2; more highly magnified. Characters as in fig. 2; *r*, Radiolarian shells, ... × 300

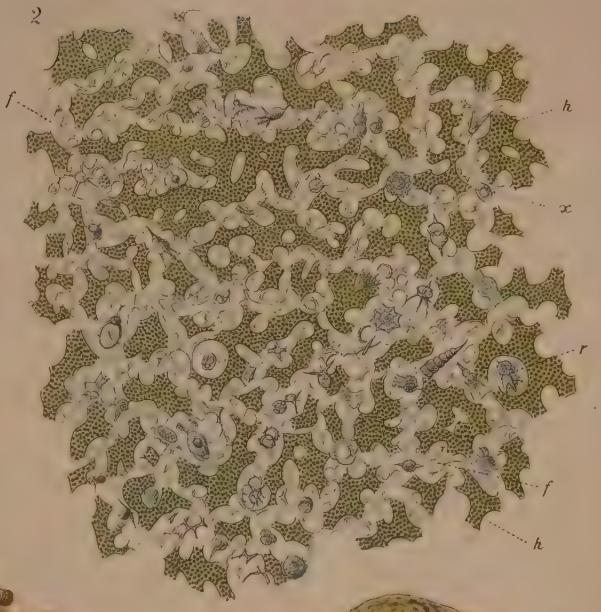
Fig. 4. Spongin-lamellæ of the skeleton (*f*), without the imbedded xenophya, observed in glycerine. *h*, a forked tube of the hydrorhiza, . × 300

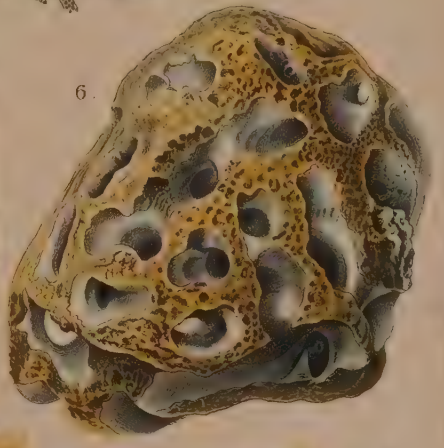
Fig. 5. A single Radiolarian shell, enclosed by a spongin-sheath; from the edges of the sheath arise spongin-lamellæ (*f*), . . . × 300

Figs. 6, 7. *Cerelasma lamellosa*, n. sp. (p. 47).

Fig. 6. A portion of the sponge, with a partial section through the surface, . × 4

Fig. 7. A small portion of a section through the sponge. *f*, spongin-lamellæ; *x*, xenophya (sponge spicules and mineral particles), . . × 300





F. Haeckel and A. Giltsch Del. A. Giltsch Jena, Lithogr.

1 - 7. CERELASMA, 1 5. C. GYROSPHAERA, 6, 7. C. LAMELLOSA.

PLATE VII.

Family PSAMMINIDÆ.

Genera *Psammina, Psammopemma, Holopsamma.*

PLATE VII.

PSAMMINIDÆ.

Figs. 1A–1D. *Psammina plakina*, n. sp. (p. 35).

Diam.

Fig. 1A. Facial view of the discoidal sponge, ... × 5

Fig. 1B. Marginal view of the same, ... × 5

Fig. 1C. Vertical section through the discoidal sponge. *g*, its gastral cavity; *o*, exhalent opening (osculum); *i*, inhalent openings (dermal pores); *k*, flagello-chambers; *e*, eggs (partly in segmentation); *x*, xenophya (*Globigerina* shells); *x'*, upper plate of the pseudo-skeleton; *x''*, lower plate of the same, ... × 70

Fig. 1D. A small portion of the same section; more highly magnified. Characters as in fig. 1C, . × 200

Figs. 2A–2D. *Psammina globigerina*, n. sp. (p. 36).

Fig. 2A. Facial view of the discoidal sponge (superior face). The whole surface is protected by a carapace composed of *Globigerina* shells, ... × 20

Fig. 2B. Marginal view of the same, exhibiting the corona of exhalent openings (*o*), on the peripheral edge of the discoidal sponge, ... × 20

Fig. 2C. Horizontal section through the discoidal sponge, exhibiting the radiating network of the symbiotic Hydroid, expanded in the medullar substance, between the two parallel cortical plates, ... × 20

Fig. 2D. A portion of the medullar parenchyma, after the removal of the calcareous shells by hydrochloric acid. Two different branched canal-systems are visible, the yellowish canals of the sponge, not anastomosing (*c*), and the dark greenish brown reticular canals of the symbiotic Hydroid (*h*). The maltha includes some Radiolarian tests (*r*), × 200

Fig. 3. *Psammina nummulina*, n. sp. (p. 37).

Fig. 3. After removal of the upper dermal plate, the soft medullar disc is visible, in which the network (*h*) of the symbiotic hydrorhiza (*Stylactis?*) is expanded, . . . × 4

Figs. 4A, 4B. *Psammopemma radiolarium*, n. sp. (p. 41).

Fig. 4A. Lateral view of the sponge, ... × 2

Fig. 4B. Basal view of the same, ... × 2

Fig. 5. *Psammopemma calcareum*, n. sp. (p. 41).

Fig. 5. The turbinate sponge, seen half from above, half from the lateral side, . . . × 3

Figs. 6A, 6B. *Holopsamma argillaceum*, n. sp. (p. 39).

Fig. 6A. Lateral view of the sponge; *o*, oscula, ... × 2

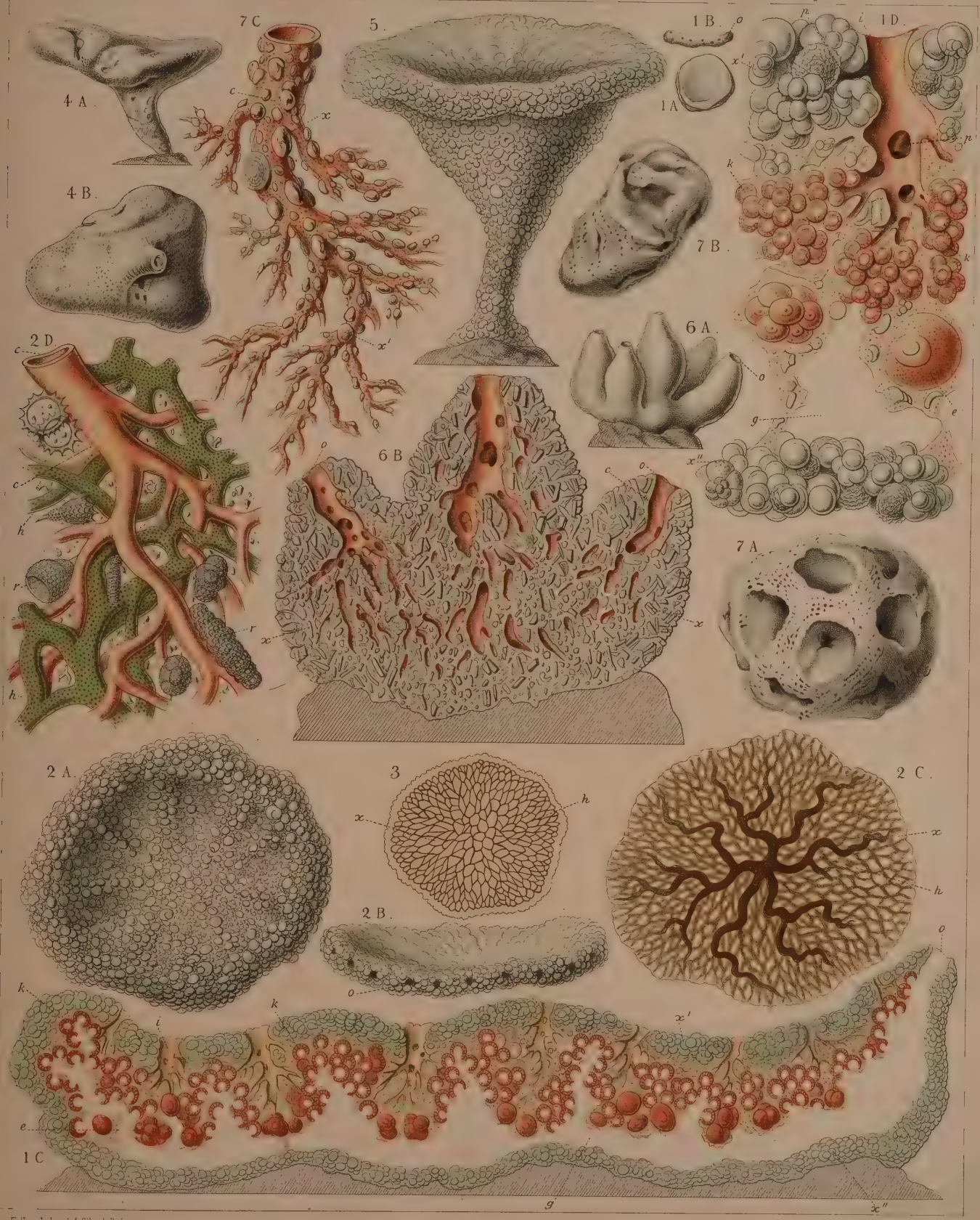
Fig. 6B. Vertical section through the sponge, exhibiting the branched canals (*c*) and their oscula (*o*). *x*, xenophya, ... × 5

Figs. 7A–7C. *Holopsamma cretaceum*, n. sp. (p. 39).

Fig. 7A. Superior view of the sponge, drawn by Miss Traill, ... nat. size

Fig. 7B. Inferior view of the same, ... nat. size

Fig. 7C. A branched canal of the sponge, isolated after the removal of the calcareous pseudo-skeleton, × 20



1-3 PSAMMINA, 1. P. PLAKINA, 2. P. GLOBIGERINA, 3. P. NUMMULINA,

4,5. PSAMMOPEMMA, 4. P. RADIOLARIUM, 5. P. CALCAREUM,

6,7. HOLOPSAMMA, 6. H. ARGILLACEUM, 7. H. CRETACEUM.

PLATE VIII.

Family AMMOCONIDÆ.

Genera *Ammolynthus*, *Ammosolenia*, *Ammoconia*.

PLATE VIII.

Ammoconidæ.

Figs. 1A–1C. *Ammolynthus prototypus*, n. sp. (p. 27).

Diam.

Fig. 1A. A complete specimen, exhibiting the pores (*p*) in the thin wall of the urn-shaped body. The greatest part of the wall is composed of various Radiolarian shells cemented together by a scanty maltha. The simple gastral cavity opens above by a cylindrical osculum (*o*), ... × 50

Fig. 1B. Transverse section through the basal portion of the body (semi-diagrammatic). *r*, Radiolarian shells; *m*, maltha of the mesoderm; *e*, eggs; *v*, germinal vesicle; *n*, remnants of the flagello-epithelium; *p*, pores, ... × 200

Fig. 1C. A small piece of the body-wall, seen from the inside. In the clear maltha (*m*) between the Radiolarian shells are visible single eggs (*e*) and amœboidal wandering cells (*a*); some pieces of the entodermal flagellated epithelium (*n*) are visible; *p*, pores, . × 150

Fig. 2. *Ammolynthus haliphysema*, n. sp. (p. 28).

Fig. 2. *o*, osculum; *p*, pores; *x*, xenophya (Globigerina ooze), . . . × 8

Fig. 3. *Ammosolenia rhizammina*, n. sp. (p. 29).

Fig. 3. A small corm, composed of eight persons, ... × 6

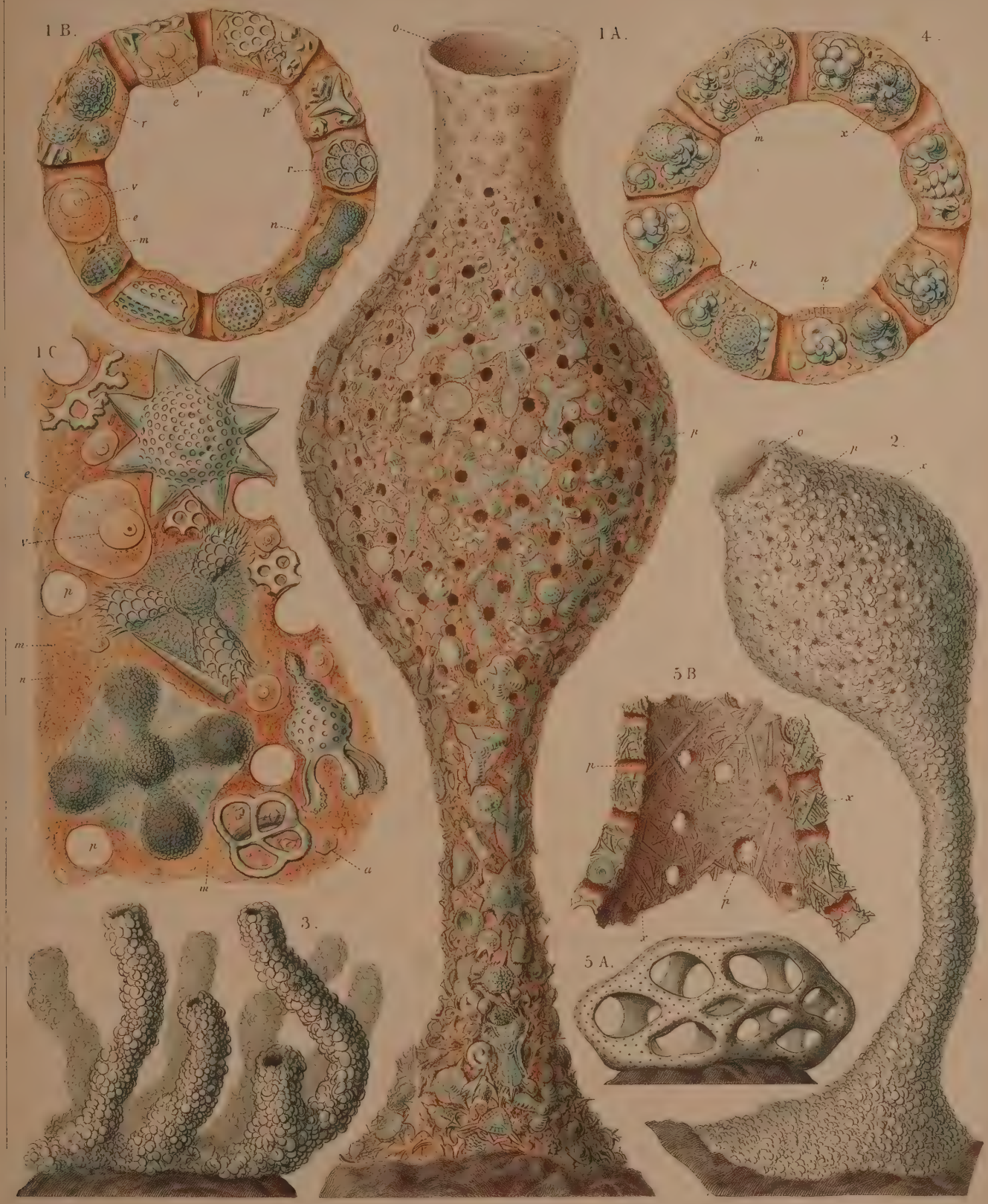
Fig. 4. *Ammoconia auloplegma*, n. sp. (p. 31).

Fig. 4. Transverse section through a cylindrical branch of the reticular sponge (semi-diagrammatic); *n*, flagello-epithelium; *m*, maltha; *x*, xenophya (Foraminifera shells); *p*, pores, . . . × 50

Figs. 5A, 5B. *Ammoconia sagenella*, n. sp. (p. 31).

Fig. 5A. The reticular body of the sponge, composed of anastomosing cylindrical tubes, ... × 4

Fig. 5B. A small portion of the porous wall of a cylindrical tube, seen from the inside. *x*, xenophya; *p*, dermal pores, . . . × 200



E. Haeckel and Giltsch Del. A. Giltsch Jena Lith. & Imp.

1, 2. AMMOLYNTHUS, 1. A. PROTOTYPUS, 2. A. HALIPHYSEMA, 3. AMMOSOLENIA RHIZAMMINA.
4, 5. AMMOCONIA, 4. A. AULOPLEGMA, 5. A. SAGENELLA.

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